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RURAL ECONOMY AND PRODUCTION.

Rural Economy and Production in the Tropics.

So many of the World's tropical products are derived from perennial crops that there has been a tendency for those concerned with their production to concentrate on a special crop without regard to its particular place in the agriculture of the country. Thus, a community of tea planters, coffee planters, sugar planters, &c., has arisen whose knowledge is, in general, confined to the production of one particular commodity.

As far as British Colonies are concerned, this concentration of effort on a single crop is perhaps only natural since an industrial country like Great Britain has to a large extent been dependent for its food supply on other countries. Thus, the problem of the local production of food for the agricultural population has not only been given little consideration at home, but has, in contrast with foreign countries owning Colonial possessions, also been practically disregarded by those interested in the production of tropical products in our Colonies. Furthermore, most tropical products when first introduced into World commerce have commanded luxury prices and the cost of production has had little relation to the profits derived from the industry. It is found, therefore, that as long as large profits have been made, little consideration has been given to the cost of feeding agricultural labour.

Another aspect in the production of tropical products which affects some Colonies is that in the early days little value was placed on land because there did not exist the population to work and develop it. In such countries land could easily be obtained by private enterprise, but production was only possible with the help of immigrant labour. As long as profits were considerable, plantation industries could not only afford to pay for the cost of such immigration, but were also able to import the food stuffs needed by the immigrants. In many such places the particular crop produced has come to be looked upon as the country's mainstay, and its finances have largely depended on it.

This concentration on the production of particular tropical products has tended to influence the development of many of our Colonies in that the export of tropical products has been considered as the *sine qua non* of advance. In

some cases the special industry has been developed to such an extent, without regard to other essential home products, that it is either no longer self-supporting or can no longer meet the competition of other countries where, on account of the ample food stuffs and the lower cost of living similar products can still be produced at a profit.

In the competition of tropical products produced in different parts of the world, those countries which are not independent as regards their food stuffs and where in consequence the cost of living is relatively high, are the first to feel the effects of price competition. In order to counteract this advantage which other parts of the tropics possess, most of the original Agricultural Services in the Colonies came into being. The result has been that in the early days of these Agricultural Departments the main effort has not necessarily been towards improving the agriculture of the country as a whole, but rather the improvement of the particular crop on which the Colony has become dependent for its existence, or in the search for other crops which might prove more profitable. Research has therefore, mainly been directed towards the improvement of yields either per unit of area or per unit of labour employed. Undoubtedly valuable results have been obtained. In the sugar industry, for example, yields have been greatly increased by the breeding of new varieties of cane, improving systems of manuring or of cultivation and by controlling diseases. Such improvement can, however, only be transitory, because successful competing countries are just as capable of organising research and this often more cheaply, to increase their production.

Research, however, is not the only factor to be taken into consideration. Although it has enabled the rubber planter to produce considerably more than double the amount of rubber per unit of area than he did twenty years ago, yet the grower is infinitely worse off now than he was then, because no means have yet been found to deal with this increased production, while prices have fallen so greatly that it does not now pay to tap the trees. In fact there is hardly a profitable tropical planting industry at the present time. Some countries, it is true, can still make these industries pay because of the low cost of living and of labour.

The problem, therefore, seems to be not to lower the cost of production by increasing the unit yield, but rather to reduce the cost of production by reducing the cost of labour without reducing its efficiency or the standard of living. This can best be done by trying to discover where the local agriculture of the country is at fault and by so adjusting the balance of production of agricultural necessities that one part of the agricultural industry is complementary to the other.

Present World conditions are forcing this aspect of agriculture on to the tropics. The low value of export crops has led to a limitation in producing areas. At the same time yields are falling because the industry can no longer afford to invest as much money on cultivation and research. With this reduction in the production of export crops, many farmers are now turning their attention to the production of necessities. For example, in the Gambia when the price of groundnuts was remunerative, rice was regularly imported from the East to feed those growing this crop. Groundnuts at present prices, however, cannot be produced profitably when this expensive method of feeding the people is employed. In order therefore to feed the groundnut producer it has become essential to make the country self-supporting in the matter of food grains, since the latter can be produced in the country at a much lower cost than that at which they can be imported.

It is this elasticity in the agricultural industry which enables the farmer to exist; for if he finds that he cannot profitably sell what he considers are his money crops, he is able to produce most of the necessities of life. If these in turn are produced in excess he can generally dispose of his surplus at a profit among the equally necessitous industrial population. This seems to be an opportunity for an Agricultural Department to extend its sphere of usefulness by bringing about an adjustment of the agriculture of the country and make it better able to face competition, through taking advantage of every means of lowering the cost of living without reducing the efficiency of the producer.

H. C. Sampson.

REVIEWS.

The Hawaii Sugar Manual (1931-32).

By A. B. Gilmore. $10.00 (U.S.A. currency).

This Manual is the fourth of the well-known series published by Mr. Gilmore. The information contained in the volume was obtained through the co-operation of the Hawaiian Sugar Planters' Association, the Experiment Station, The Sugar Agencies, and the Executives of the various sugar companies. Each and every Sugar Plantation is dealt with separately, and full information is given with regard to both the Agricultural Equipment and Practices (Transport Equipment, Irrigation, Varieties, Land Preparation, &c.) and also the Factory Equipment. All are set out in orderly fashion in a more or less standard form, and the comparison of different mill openings used, for example, is easily carried out. Besides this large volume of data about the plantations, a series of useful technical papers is presented covering a whole range of subjects from the feeding of live stock to the firing and care of locomotives. Most of these articles are illustrated by means of well reproduced photos and graphs.

J. G. D.

THE VEGETATIVE PROPAGATION OF CITRUS.

Results of Preliminary Experiments.

By R. E. Hunter, M.Sc.

Introduction.

In a previous note (1) a description was given of the Solar Propagator and its application to the rooting of "semi-hardwood" cuttings of Citrus. In the present communication a description is given of all the methods of vegetative propagation which have been applied experimentally to various Citrus species. The ultimate aim in view has been the production of uniform plants suitable for use as rootstocks. Propagation has been achieved by means of roots, stems and leaves. In stem propagation both old stems, "hardwood" propagation, and young stems, "softwood" or "semi-hardwood" propagation, have proved successful with many species. For reasons which are given below, the further investigation of hardwood propagation was soon discontinued and all effort concentrated upon the more promising softwood type. The results obtained by various methods of hardwood propagation are described below in some detail for purposes of record and in the hope that they may be of some use to other investigators in the field of vegetative propagation.

Materials and Methods.

Citrus Species.

The following Citrus species and varieties have been used to a greater or lesser extent in the experiments on propagation :—

Citron :—*Citrus medica L.*

Ponderosa lemon : — *C. medica L. var Limonia Osb.*

Rough lemon :—*C. medica L. var. Limonia Osb.*

Trinidine lime :—This variety appears to have affinities with the Citron.

Rangpur lime :—*C. medica var. acida. C. aurantifolia, Swingle.*

Kusai lime :—*C. medica var. acida, C. aurantifolia, Swingle.*

West Indian Lime :—*C. medica var. acida. C. aurantifolia, Swingle.*

T. I. lime :—*C. medica var. acida. C. aurantifolia, Swingle.* This is a hybrid lime raised by the Trinidad Department of Agriculture.

Sour Orange :—*C. aurantium L. var. amara.*

Grapefruit :—*C. decumana L. C. maxima (Burm.) Merril.*

Shaddock :—*C. decumana L. C. maxima (Burm.) Merril.* The Shaddock has also been separated as *C. grandis Osbeck.*

C. nobilis :—A loose skinned type with acid lime-like fruits introduced from Burma.

C. hystrix, D. C.

C. excelsa, Wester :—Provisional identification. Introduced from Burma.

In the earlier experiments, which were mainly with hardwood propagation, the numbers of branches and cuttings used in each experiment was of necessity rather small, owing to lack of experimental material. The plants furnishing the material were grown from seed and at first were not of sufficient size to yield large numbers of cuttings. In many cases the material had to be collected from several plants which introduced an error due to seedling variation. This error was reduced as far as possible by selecting plants of similar growth characteristics.

The physiological age of material used in the experiments was judged approximately by the position it occupied on the parent plant, and from its appearance, used in conjunction with a knowledge of the growth habit of citrus. The branch extension of mature citrus trees takes place by means of successive "flushes" or "cycles of growth". At certain times of the year there are main growth flushes when most of the branches extend in length. At almost any time, however, a few branches may be found in the actively elongating condition. During the dormant period when the branch is not elongating, very little secondary increase in stem diameter takes place along the length of the ultimate flush, *i.e.*, the last length of stem to be produced. Marked thickening only begins when the terminal bud becomes active and adds a new length of branch. Secondary thickening is to a certain extent cyclic but succeeding cycles tend to merge into one another producing a steady increase in stem diameter as the particular branch ages, and the end of the branch grows further away from the original point observed. Secondary thickening of the branch is correlated externally with changes in the appearance of the stem surface. The epidermis becomes ruptured giving the stem a russetted appearance. The russetting first appears on small areas just above those buds which are situated towards the base of the particular flush and it gradually appears just above all the buds of the flush, spreading basifugally. Later the russetting appears as lines and streaks roughly parallel to the buds and finally becomes general all over the stem. In some species the russetting is delayed, as, for instance, in *C. excelsa*, where very little may be apparent except just above the buds, even on growth flushes of the third order in age. The growth of young Citrus plants is less periodic than in older ones, the main seedling axis tending to grow steadily and continuously for about two years. In this respect, however, there is a certain amount of variation between the different species.

Information as to the rooting responses of various species has been sought by the following methods :—

1. *Root Cuttings* :—Root cuttings have been taken from trees varying in age from two to five years. The cuttings were made to a length of

about six inches and were taken from roots running horizontally at a depth of about eight inches. The root pieces were set in sand in the Solar Propagator and were placed in a horizontal position covered by sand to depth of from one to two inches.

2. *Layering* :—For layering, branches were bent downwards and covered about two inches deep with sand and grit. In some cases the branches were left for a time after bending downwards until young shoots had developed to a length of about two inches, at which time the sand and grit were applied just leaving the tips of the young shoots uncovered. The layers were kept moist by watering daily.

3. *Wiring or Strangulation.*—Branches propagated by this method were surrounded by a couple of turns of soft brass wire drawn up fairly tightly and applied just below the region of the stem from which it was intended that the roots should develop. The stems were bound up at the region of the wire with damp moss which was kept moist by watering.

4. *Marcottage.*—This method with minor differences is variously known as Air Layering, Circumposition and Gootee. It is an ancient method of propagation which may have originated in the East and is mainly applied to woody plants which are not easily propagated by cuttings. In the experiments a ring of bark about half an inch wide was removed from the stems to be propagated. The exposed wood was lightly scraped to make sure that all soft bark-tissues were removed and the ring-barked region bound up with damp moss and watered as in strangulation.

5. *Ringed-Hardwood Cuttings.*—In experiments with this type of cutting the stems were ring-barked as in marcottage but the ring was left bare and not bound up with moss or any other medium. When the upper cut made in ring-barking had healed and formed a visible callus tissue, the stem was clipped off and set as a cutting. Care was taken not to injure the healed surface as this becomes the base of the cutting when set in the rooting bed. For making these cuttings well matured stems were used such as had become russetted as explained above. They were cut to a length of about 12 inches. Five to seven leaves were left at the top, the rest being removed when the cuttings were set.

6. *Hardwood Cuttings.*—The material used in making cuttings of this type was similar to that used for ringed hardwood cuttings, differing only in that as the cuttings were made and set directly in the rooting bed, they were unhealed at the basal ends.

7. *Semi-hardwood or Softwood Cuttings.*—The term semi-hardwood applied to this type of cutting was apparently coined by Swingle (6) to distinguish it from the horticulturists' common use of the term softwood, which is generally applied to a very sappy type of cutting. The cuttings consisted of leafy twigs of the last flush or growth cycle. After the growth in length of each flush ceases, the leaves, which are yellowish in the juvenile condition, begin to develop their full green colouration. As the leaves become dark green the woody part of the stem begins to harden and the stems seem somewhat to dry. As far as possible twigs were selected for semi-hardwood cuttings the leaves of which had just developed the full green colour. The cuttings were made to a length of from six to ten inches, all leaves being removed with the exception of five or six at the upper end. They were clipped from the parent tree with sharp secateurs and were set immediately in the Solar Propagator. The cuttings were made as far as possible on dull or rainy days when there was less chance of their wilting during transport to the Propagator.

From the results of early experiments the use of "heel" cuttings was advocated (1). However, experimental evidence which has since accumulated indicates that there is on the whole no special advantage in making cuttings with a "heel" of older tissue.

8. *Leaf Cuttings.*—Experiments have been carried out with two types of leaf cuttings. In the first type the cutting consisted of the leaf only, the leaves being removed by cutting through the leaf stalks close to the stem; whilst in the second type the leaf was removed together with a slip of stem tissue which included the bud, the cut being made in exactly the same way as in the removal of a bud for shield budding. Leaf cuttings were made with the same precautions, and received the same treatment as semi-hardwood cuttings.

Propagators.—A description of the Solar Propagator has previously appeared (1). This is a device for obtaining a certain amount of bottom heat for the rooting bed by utilizing the radiant energy of the sun. The rooting chamber has a close fitting lid and thereby the atmosphere inside is kept saturated with moisture. In the Solar Propagator the semi-hardwood, the leaf and the root cuttings were set. Watering was carried out once daily, in the early morning, and the Propagator was thereafter not opened again during the day, as with the leafy cuttings of the softwood type every precaution has to be taken to prevent the leaves from drying.

The hardwood cuttings were set in ten inch pots in a tank in the greenhouse. The tank was covered with light wooden frames upon which was nailed a single thickness of Victoria lawn. (*See* photograph, Pl. II, Fig. 5.) The frames have since been glazed, which keeps the inside atmosphere at a higher degree of moisture saturation than formerly. However, it worked quite satisfactorily with the lawn covering provided the sides and bottom of the tank were sprayed over with water twice daily to keep up the humidity.

Rooting Bed.—Well washed sand has been used for the rooting bed and two types have been tested in the experiments. The first was a coarse

THE VEGETATIVE PROPAGATION OF CITRUS.

Plate I.

FIG. 1.—*This illustrates a typical hardwood-propagated plant. It is a sour orange about eight months old. The thick hard stem is quite unsuitable for budding.*

FIG. 2.—*This shows the type of plant produced from a semi-hardwood cutting. The plant is West Indian lime planted out for three and a half months.*

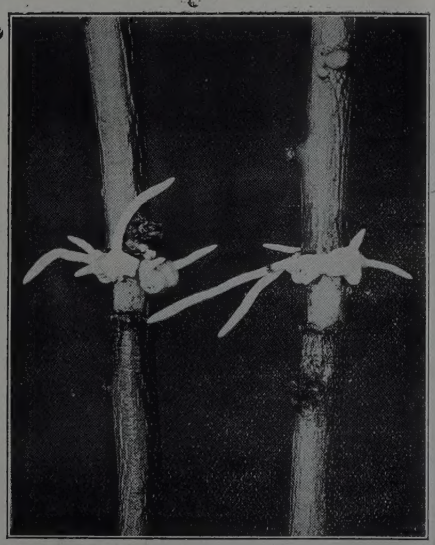

FIG. 3.—*This photograph is of two branches rooting from marcottage. It shows that the position of the ring-bark is immaterial, one being ringed below and one above the bud. The plant is West Indian lime.*

FIG. 4.—*Shows the production of roots from the bases of two ringed hardwood cuttings of Rangpur lime.*

THE VEGETATIVE PROPAGATION OF CITRUS.

Plate II.

FIG. 5.—*This illustrates the propagator used for hardwood cuttings. It consists of a tank having light frames covered with lawn. Inside the cuttings are set in sand in* 10 *inch pots.*

FIG. 6.—*This is a root cutting of "Citrus excelsa". The shoot in this case has not arisen from the callus at the cut end. It will be noted that the shoot has produced only one slender root, other roots having developed from the root piece.*

sea beach sand which contained a high proportion of broken shell fragments. The second was a fine quartz sand of which there are several deposits in Trinidad.

Results of Rooting Experiments.

Root Cuttings.

Soon after they were set, the root pieces began to produce callus tissue at both cut ends, but chiefly at the proximal end, that is, the end of the cutting which was towards the centre of the plant when the cutting was still part of the parent tree. Later, buds appeared upon the callus at the proximal end and occasionally from other parts of the cutting. (*See* photograph, Pl. II, Fig. 6.) The buds developed into leafy shoots and when these had remained in the Propagator for a sufficient length of time, roots were formed from the bases of the shoots. (*See* photograph, Pl. III, Fig. 7.) It will be noted from the photographs that some species root from the shoots with far greater facility than do others. The West Indian lime (Fig. 7) roots much more easily than *C. excelsa* (Fig. 6). The cuttings illustrated in the photographs had been set for approximately nine months, at the end of which time over 50 per cent. of the cuttings in each species had rotted without producing any shoots. Root pieces of *C. nobilis* set at the same time all rotted without producing shoots.

Laboratory experiments of a preliminary nature indicate that root cuttings are very sensitive to over-watering, which causes decay before a callus tissue can develop. The use of a coarse sand for the rooting bed, the very careful control of watering and the use of a considerable degree of bottom heat would probably give better results for callusing and shoot production. These difficulties rule out the root cutting method as a practical measure. There is in addition the unwillingness of Citrus species to produce roots from the shoots except in those species most easily propagated by any of the methods used.

The bases of the shoots produced from root cuttings are perfectly etiolated, having pushed up through the rooting bed, but root production does not appear to be stimulated except in the readily rooting species. With a number of plants, etiolating the stem greatly facilitates root production, but with many Citrus species it appears to have little effect. These observations are in accord with some preliminary tests which were made with etiolated stem cuttings.

Layering.

The success of layering as a horticultural practice is generally considered to be due in large measure to the production of etiolated shoots. In experiments with Sour Orange and Grapefruit, the buds on the layered branches which were covered with sand and grit, failed to develop. From this it appears that the buds of Citrus are very susceptible to pressure and will not grow out if covered by even a shallow layer of sand. In some experiments, the buds were allowed to grow out to a length of about two inches before the sand and grit were applied. The shoots were then covered, leaving the tips free. This is a modification of the layering method which is successfully applied to the propagation of apple and quince stocks (2). Although the shoots are not etiolated they root satisfactorily if covered while still young and tender. In the Citrus experiments the method proved quite unsuccessful and no rooting occurred. The two species used, Sour Orange and Grapefruit, are not particularly easy to propagate and possibly greater success might have attended the use of the more easily propagated species.

Wiring.

Some success has attended the use of this method. Kusai lime and Grapefruit have been rooted, but a few tests with Sour Orange were quite unsuccessful. The method requires a considerable time for root production and as more rapid ways of rooting Citrus were found, the experiments were soon discontinued. Roots are only formed after the increase in diameter of the woody cylinder of the stem has constricted the bark tissues, by pushing them outwards against the coil of wire. The constriction prevents the downward translocation of food substances in the bark and as these accumulate above the wire, greatly increased stem growth takes place at this point. If the region above the wire is kept moist with damp moss, damp coconut fibre, or earth, roots are thrown out.

In this manner branches of Kusai lime wrapped up with damp moss were well rooted at the end of three months and Grapefruit after five months.

Marcottage.

This is probably the most certain method of propagating woody plants. By this method most species of Citrus can be rooted. In the early experiments the region of the stem which had been ring-barked was covered with grit and sand or bound up with coconut fibre, and watered every day. With both these treatments a very large callus tissue developed from the upper edge of the ring-bark but no roots were formed. Paring the callus, a procedure which assists rooting in some plants (5), had no beneficial effect. Finally, success was achieved by using damp moss with which to bind up the ring-bark. The moss "ball" so formed was surrounded on the outside with a sheet of rubber cut from old automobile tyre tubes and tied on somewhat funnel-wise. Water was given every day and it was found that the rubber efficiently prevented the moss from drying out in between waterings. It thus appeared that neither the sand and grit nor the coconut fibre maintained sufficiently wet conditions for root formation. Experiments have shown that the position of the ring-bark in relation to the buds on the stem, whether nodal of internodal, is quite immaterial. The roots spring from the region of the callus tissue and not from any

pre-formed root initials as in some plants (3). (*See* photograph, Pl. I, Fig. 3, which shows rooting marcots of West Indian lime, one with the ring of bark removed just below a bud and the other with the ring a little way above a bud.)

The exact age of the stem has apparently little effect upon rooting, for, in different experiments branches varying in age from mature current flushes, *i.e.*, the last growth cycle, having stems of approximately quarter inch diameter, and other branches of several cycles of growth having stems of about one inch diameter were rooted with equal facility. Below is a table giving approximately the number of days which elapsed from ring-barking to the first appearance of roots for several different species:—

Citron	20-25 days.
West Indian lime	20-30 days.
Kusai lime	20-30 days.
C. excelsa	25-40 days.
Sour Orange	30-50 days.
Grapefruit	30-50 days.
C. nobilis	130 days. Result of one test only.

Ringed Hardwood Cuttings.

The special feature of this type of propagation is that the cutting is set with a pre-formed basal callus. The bark tissue is already healed when the cutting is removed from the parent tree. This method was developed when early experiments with ordinary hardwood cuttings failed, owing to decay setting in at the basal ends which failed to callus when the cuttings were set. In most of these experiments the cuttings were ring-barked and left on the tree for 20 days before being clipped off and set. A few experiments on the effect of removal or non-removal of the leaves at the time of setting were inconclusive; there were, however, indications that if all the leaves were left on the cutting, then greater care had to be taken to keep the air in the Propagator thoroughly moisture laden. If the air at any time became too dry the leaves lost water and thereby tended to dry out the stems. Cuttings bearing from five to six leaves which were successfully rooted, developed a larger number of roots, the roots were thicker and bore more secondaries than those cuttings which were completely defoliated. Some species, and in these experiments especially West Indian lime, tended to produce leafy shoots before any roots had formed. Having no water absorbing organs, the shoots wilted rapidly and the cuttings died. In experiments with cuttings ring-barked for 20 days and then set, the approximate number of days from setting to first appearance of roots is given for a few species in the table below:

Citron	15-20 days.
Ponderosa lemon	25-40 days.
Rangpur lime	25-40 days.
Sour Orange	60-80 days.

It is probable, however, that the 20 days given was not the optimum period for all species. In one experiment with Rangpur lime the period wa varied from five days to 30 days with five-day intervals. The cuttings were set for 30 days and then dug up and examined, with the following results:

Days Ring-Barked.	*Number of Cuttings.*	*Cuttings Rooted 30 Days Set.*
0 Control	5	0
5	5	1
10	5	2
15	5	5
20	5	1
25	5	1
30	5	1

For the Rangpur lime the optimum period for ring-barking was clearly in the neighbourhood of 15 days.

Hardwood Cuttings.

Citrus cuttings of this type are not easy to root and on the whole little success has attended the use of this method. Failure is usually due to the cuttings decaying from base upwards. Only in the easily propagated species was a reasonable percentage of rooted cuttings obtained. Laboratory experiments upon the callusing of hardwood cuttings have shown that no callus forms if the cut end is continuously covered by a film of water. In practice this means that hardwood cuttings must only be watered very sparingly in the early stages of propagation. Later, when the basal ends have callused, watering may be increased to stimulate root production.

Semi-Hardwood Cuttings.

Cuttings of this type have been rooted fairly successfully in the Solar Propagator. Compared with hardwood cuttings, semi-hardwood cuttings callus much more readily and few cuttings have been lost owing to decay setting in at the basal ends. The different species all have their own characteristic speed of root formation. Approximate periods from setting to root formation are given below. The first figure refers to the shortest time in which the cuttings of a given batch begin to form roots. At the end of the period given by the second figure all cuttings in the batch have usually produced roots. In the slower rooting species the lack of uniformity is much more marked and even at the end of several months there may be some cuttings still not rooted. When this occurs the second figure is omitted.

Species.	*Days to Root Formation.*
Citron	10-15
Trinidad lime	10-15
Rangpur lime	15-35
Kusai lime	15-35
West Indian lime	15-35
C. excelsa	25-
C. hystrix	30-
Sour Orange	30-
Shaddock	35-
C. nobilis	250-

Leaf Cuttings.

The first type of leaf cutting, consisting of leaf only, has not been found very successful. The time taken to root is longer than is the case with semi-hardwood cuttings, and after rooting a considerable time elapses before any shoot is formed. These eventually appear as tiny shoot-buds upon the callus developed from the cut end of the leaf stalk. The second method in which a portion of stem tissue is removed along with the leaf, has been very successful. These have rooted in just about the same number of days as the corresponding semi-hardwood cuttings. When the leaf is well established, the bud breaks and makes a good strong shoot. The method has not long been tried but appears promising. Many more cuttings can be taken from one tree and they occupy less space in the Propagator and are more easily handled than is the case with semi-hardwood cuttings.

Discussion of Results.

The hardwood methods of propagation, comprising wiring, marcottage, hardwood cuttings and ringed-hardwood cuttings, all suffer from one serious defect from the point of view of root-stocks, which is, that the type of plant produced is not suitable for use as stock for budding. The plant produced consists of a hard stem, the bark of which does not "slip" easily for budding, whilst the shoots which are produced in profusion at the summit of the cutting are too thin and sappy to bud for some time. (*See* photograph, Pl. I, Fig. 1.) The most promising of the hardwood methods is the ringed-hardwood cutting. This involves less time and labour than wiring or marcottage. Ordinary hardwood cuttings which require less labour are considered to be too uncertain owing to the liability to decay. One method of using the ringed-hardwood cutting is to bud the stem at the same time that the ring-barking is done. When the cutting is set it is cut at the ring-bark and also just above the bud which by this time should have taken, but should not have grown out. The cutting is then set and when rooted the scion bud will grow out along with others on the stock. The latter must be removed as they appear. This has proved successful using Citron as stock and T. 1 lime as scion. There was, however, a certain mortality of buds while the cuttings were set and before they had rooted.

The semi-hardwood or softwood methods of propagation on the whole appear the most promising. These cuttings grow away with a stem quite suitable for budding. The production of side shoots which have to be removed is probably not much more marked than in seedling stocks. Economically, the chief drawback to semi-hardwood propagation is the necessity for some fairly efficient type of Propagator, inside which the cuttings can be maintained in an atmosphere saturated with moisture until rooting takes place. The cuttings must only be made on dull rainy days or at early morning or in the evening, otherwise the leaves wilt before the cuttings reach the Propagator. Watering should be done once a day and that in the early morning so as to avoid having to open the Propagator during the heat of the day.

Reference has been made to "easy" and "difficult" species from the point of view of propagation. A rough classification of the species used in the experiments is as follows:—

Easily propagated:—Citrons, lemons, limes.

Not easily propagated:—Oranges, grapefruit.

Only propagated with difficulty:—*Citrus nobilis*.

The successful establishment of rooted cuttings may be said to take place in three phases. In the first phase the walls, of those cells which lie close to the cut surface but which have not actually been themselves injured, become suberized. Fatty substances are apparently released from these cells which oxidize upon the surfaces of the cell walls to form a varnish-like layer of suberin. This suberin deposit protects the cells from invasion by micro-organisms which cause decay. Suberization takes place best in an atmosphere saturated with moisture and under conditions of ample aeration. It is prevented if the cut surface is kept covered with a film of liquid water, for under these conditions the fatty substances leach away from the cell walls and no suberin deposit results (4). The second phase is characterized by the formation of callus tissue which arises as a result of cell division and multiplication which takes place beneath the suberized layer. The callus tissue forms a second, and still more efficient, barrier against the entry of decay organisms. The third phase is marked by the differentiation of roots from the wood cambium and their growth outwards piercing the callus tissue.

The results so far obtained indicate that callus formation, and therefore in all probability suberization first of all, takes place far more readily in semi-hardwood than in hardwood Citrus cuttings. In semi-hardwood cuttings callusing will take place under wetter conditions than are suitable for hardwood. There is some evidence also which indicates that the quantity of callus tissue formed is greater when the rooting bed is relatively dry. Rooting, on the other hand, is favoured by wetter conditions. The conditions to aim for in Citrus propagation are therefore to keep the rooting bed on the dry side at the start to encourage suberization and callusing. Later on the watering should be increased to check excessive callus formation and to stimulate rooting. Semi-hardwood propagation is more successful than hardwood because far less care is required in controlling the preliminary watering. The success of ringed hardwood cuttings is due to their starting with a ready formed basal callus.

Some of the factors which have an effect upon the speed of rooting in semi-hardwood cuttings are receiving special attention. One of the most important of these is undoubtedly the age of the material. The most recent experiments seem to

indicate that cuttings should be made from material the leaves of which have not yet developed their full dark green colour. The stems of such material are quite soft and fairly "sappy". Another factor which seems to be of importance, though results have so far been rather conflicting, is the size of the sand particles in the rooting bed. The indications are that if the sand can be kept sufficiently wet the size and type of sand grain is quite immaterial. If, however, water supply is cut down, then in the coarser grades of sand a large development of callus takes place and rooting is retarded. A treatment, which may prove of use in hastening rooting, is the soaking of the cuttings previous to setting in dilute solutions of potassium permanganate. Some encouraging results have been obtained, but require confirmation on a large scale.

Summary.

1. The results obtained from preliminary experiments on the Vegetative Propagation of various Citrus species are described.

2. The methods of Propagation which were used comprised: Root Cuttings, Layering, Wiring, Marcottage, Ringed-Hardwood Cuttings, Hardwood Cuttings, Semi-Hardwood Cuttings and Leaf Cuttings.

3. It has been found that the relatve speed of root formation in stem propagation is a specific attribute. The relative rates of root formation of various species remain approximately the same whatever the method of propagation used.

4. Semi-Hardwood cuttings of Citrus are propagated with much more certainty than are Hardwood, this being due to the inability of Hardwood cuttings to callus at the basal ends except under very carefully controlled moisture conditions of the rooting bed. Semi-Hardwood cuttings callus satisactorily under far wetter conditions than do Hardwood, and therefore demand less care in watering.

References.

(1) Hunter, R. E.—The Propagation of Citrus by means of the Solar Propagator. *Tropical Agriculture*, Vol. VIII, No. 4, 1931.

(2) Knight, R. C. and Witt, A. W.—The Propagation of Fruit Tree Stocks by Stem Cuttings. II. Trials with Hard and Soft-Wood Cuttings. *Journ. Pomol. & Hort. Sci.*, 6, p. 56, 1927-28.

(3) Lek, H. A. A. van der—Over de Wortelvorming van Houtige Stekken. *Meded. Landbouwhoogesch. Wageningen*, 1925.

(4) Priestly, J. H. and Swingle, C. F.—Vegetative Propagation from the Standpoint of Plant Anatomy. *U. S. D. A. Tech. Bull.*, 151, p. 11, 1929.

(5) Stewart, L. B.—Methods of Propagation. *Journ. Roy. Hort. Soc.*, 52, 1927.

(6) Swingle, W. T., Robinson, T. R., and May, E.—The Solar Propagator. *U.S.D.A. Circular* 30. 1924.

QUICK VINEGAR PRODUCTION.

Quick Vinegar Production from Sugar-Cane Products.

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Introduction.

In the manufacture of cane syrups from the juice of sugar-cane a certain amount of inversion of sucrose should take place or subsequent crystallisation of sugar will result. Such inversion can be brought about in many ways and that most usually adopted consists in lowering the pH of the clarified juice by the addition of acids. Strong acids, like sulphuric, can be used in small quantities, but their use has been proscribed by the food laws of some countries.

Acetic acid, though very poorly dissociated as compared with the strong acids, may be used with satisfaction in the manufacture of syrup because of:

(1) Its economical production from cane juice by fermentation, and

(2) Its removal from the syrup during concentration. Owing, however, to its low dissociation, relatively large quantities of acid are necessary to produce the requisite inversion. The method commonly employed in Barbados to obtain the acid, consists merely in allowing a large quantity of cane juice to become sour. Fermentation is spontaneous and inoculation occurs by yeasts and bacteria from the atmosphere. The acidity obtained is low, seldom exceeding 0.5 per cent. acetic acid. Furthermore, a great deal of the alcohol generated is lost while large storage requirements are needed. By this method several weeks would be required to attain a concentration of about five per cent. acetic acid in the juice, with a further possibility that the resulting product might be ruined by deleterious fungi, &c.

This investigation of a quick vinegar process for sugar-cane products was undertaken for the purpose of obtaining a uniform certain supply of relatively strong vinegar in the shortest possible time. The work was chiefly done with cane juice, but its scope was subsequently extended to include cane syrups, molasses, and even vacuum pan molasses. Incidentally the process is also capable of producing clear bright cane sugar vinegars of excellent flavour, good keeping qualities, quite suitable for table use.

Fermentation of Cane Juice.

There are two stages in the conversion of sugars into acetic acid:

(*i*) Alcoholic fermentation by yeast.

(*ii*) Oxidation of alcoholic to acetic acid by bacteria.

A simultaneous alcoholic and acetic acid fermentation had proved unsuccessful (Mitchell (1)), it was desirable to obtain rapid optimum alcoholic

fermentation before acetification was started. Hansen (2) had clearly demonstrated the technical importance and superiority of the use of pure yeast cultures in alcoholic fermentation—hence this investigation involved :

(1) The breeding and selection of a pure culture yeast capable of giving the most rapid fermentation of the juice.

(2) The determination of the optimum working conditions for this yeast.

The method of yeast selection was that outlined by Fowler (3), the sterile nutrient gelatine on which the cultures were grown for preliminary selection being made up as follows :

Gelatine	.. 175 grams.
Glucose	.. 100 do.
Ammonium sulphate ..	.. 1 do.
Calcium di-hydrogen phosphate	.. 0.1 do.
Potassium sulphate ..	.. 0.1 do.
Concentrated Sulphuric acid	.. 0.5 ccs.
Water	.. to 1 litre.

The above were heated on a boiling water bath, and some of the solution transferred to Petri dishes for sterilisation and subsequent inoculation. The yeast for inoculation was obtained from a sample that had developed spontaneously in fresh cane juice. Of the many colonies obtained, 25 pure cultures were picked, of which eventually eleven were selected for growth in the cane juice itself. The rate of fermentation of the different cultures in cane juice was ascertained by the Brix hydrometer readings over time intervals. Control experiments were also run to ensure that contamination with outside yeasts had been eliminated. As a number of preliminary experiments proved that the nutrients present in the normal juice were insufficient to maintain a rapid and vigorous fermentation, a nutrient solution was made up as follows :—

Sulphate of Ammonia ..	.. 100 grams.
Superphosphate ..	.. 5 do.
Sulphate of Potash ..	.. 10 do.
Water	.. to 1 litre.

The effect of these nutrients on the rate of fermentation (1 per cent. nutrient = 1 cc. of above solution per 100 ccs. juice) are shown in the following table :—

Table I.

	Original Brix.	Brix after 48 hrs.	
		No Nutrients.	1 per cent. Nutrients.
No. 4 Yeast	14.5	7.3	2.8
7 do.	14.5	7.0	1.2
10 do.	14.5	7.2	1.2
12 do.	14.5	8.4	2.4

Experiments also indicated that nutrients exceeding 1½ per cent. of above solution served no useful purpose ; indeed four per cent. of this retarded fermentation.

Other factors influencing the rate of fermentation were temperature and hydrogen ion concentration. Temperatures much higher than normal room temperature (84°.F.) resulted in increased rates, but also in loss of alcohol. During rapid fermentation it was found that the temperature was automatically maintained between 90-95°F. by the action of the yeast itself. No great advantage was obtained by starting fermentation at higher temperatures than around 80-85° F.

Investigations on the rates of fermentation at varying hydrogen ion concentrations revealed that the normal reaction of an average cane juice was around 5.0-5.5 and that optimum rates of alcoholic fermentation took place at pHs. slightly lower, *i.e.*, between 4.5-4.8.

Table II shows the results of growing the selected yeasts under optimum conditions.

Table II.

Brix of original juice 14.8, pH 4.5
Nutrients 1 per cent. by volume.
Yeast 1 per cent. by volume pure culture.

Degrees Brix after.	10 hrs.	20 hrs.	30 hrs.	40 hrs.
No. 1 Yeast	14.6	10.5	5.2	0.6
2 do.	14.8	11.5	6.0	3.4
3 do.	14.6	10.7	5.8	3.0
4 do.	14.8	11.9	6.2	3.4
5 do.	14.4	10.4	5.6	2.2
6 do.	14.2	10.4	5.2	0.6
7 do.	13.9	9.7	5.0	1.2
8 do.	14.4	11.5	5.6	2.4
9 do.	14.8	11.9	6.9	4.0
10 do.	14.5	10.4	5.4	1.2
11 do.	13.9	9.7	4.5	0.0
Yeast from air	14.8	14.8	14.8	14.6
Control	14.8	14.8	14.8	14.8

Yeasts Nos. 11, 1, 6, 7, 10 were selected and preserved in sterile 10 per cent. pure sucrose solution and grown repeatedly under varying conditions, with the following results :

(1) Under optimum conditions and at ordinary temperature (84°F.) No. 11 yeast was capable of fermenting an average cane juice of 15° Brix with the accumulation of 6 per cent. by volume of alcohol in 30 hours.

(2) One hundred gallons of cane juice having pH 5.5 and Brix 15.0 would require for rapid fermentation the addition of 1 lb. Sulphate Ammonia, 1 oz. Superphosphate, 2 oz. Sulphate Potash, 3 oz. Commercial Sulphuric acid.

In practice this quantity of cane juice would be inoculated at ordinary temperature with one gallon pure culture yeast. In 30-36 hours the fermented liquor would be ready for acetification.

Acetification of the Fermented Cane Juice.

The two chief requisites for acetic fermentation are :—

(*i*) A selected culture of acetic bacteria.

(*ii*) Means whereby the oxidation of alcohol to acetic acid can be rapidly and efficiently brought about.

The culture here used was selected from cane juice that had been allowed to go acid. It was grown in the culture medium recommended by Janke (4) and made up as follows :—

Potassium di-phosphate	9.4 grams.
Ammonium di-phosphate	1.0 do.
Magnesium sulphate	0.4 do.
Succinic acid	1.0 do.
Glycerine	5 ccs.

dissolved in one litre of water and 40 ccs. of 95 per cent. Ethyl Alcohol added.

To avoid subsequent contamination from the air—and yet propagate the culture—use was made of the Laboratory glass generators recommended by the Bureau of Chemistry (5). In the absence of beech shavings, generators were filled with oak shavings which had previously been boiled in water to remove any traces of pine oils, &c. A sterile fermented cane juice was used to which selected bacteria were added, and filtered air only was admitted to the generators. Acetification proceeded slowly and at the end of about four weeks a quantity of "mother of vinegar" had developed in the generators. This "mother" was subsequently used in the experimental acetifiers.

Use was made of a wooden experimental generator or acetifier about 20 inches square in section and five feet high which functioned by exposing the alcoholic liquor in thin films to the action of the acetic bacteria and the oxygen of the air. About one-sixth of the way up from the bottom of the generator a perforated false bottom was fixed and the space above this loosely packed with a suitable type of filling upon which the bacteria could develop and air circulate freely. This air was admitted through a number of holes bored in the sides of the box below the false bottom.

The alcoholic liquor was run in at a regulated rate to a small distributor box packed with cotton wicks, and distributed by the latter over the filling material down which it slowly trickled in thin films. The activity of the bacteria with which the filling material was inoculated caused the temperature to rise several degrees, the resulting current of warm air ascending and escaping through the holes in the top of the apparatus ; while at the same time fresh air was drawn in through the holes below the false bottom. Thus a constant circulation of air was automatically maintained by the working of the acetifier and the thin films of fermented liquor were continually exposed to it.

A general view of the acetifier can be seen in Plate I. The type of filler may be selected from a wide range of materials. Thus megass, charcoal, basket wicker, shavings, and crushed cane stems were tried out more or less successfully. Deal shavings first boiled in water, were chosen for these experiments and spread on shallow trays of basket wicker, no metal of any kind being used in the construction of the acetifier or trays. The filler should be innocuous to the bacteria, should be unaffected by dilute alcoholic solutions, and when packed should permit free circulation of air. Undoubtedly beech shavings are ideal, but were not procurable in Barbados.

The acetifier was operated as follows: the filling was first inoculated with the selected culture and then a small portion of fermented liquor was run in through the distributor box. After passing through, this was collected and poured back again three or four times. At the end of about 24 to 30 hours, the temperature inside the box had risen to about 95° F. and the generator was ready for continuous operation. Fermented liquor, from which most of the yeast had settled out, or otherwise removed, was fed continuously to the distributor. A clear vinegar flows away from the base and may be fed back to the distributor if a stronger vinegar is desired. After continuous operation for some months the efficiency of the generator may fall off through clogging with "mother." This type was so constructed that the front could be easily removed, and the trays cleaned and replaced. Plate II shows the generator with front removed and the nature and arrangement of the filling material, wicks, false bottom, &c.

For efficient production, the temperature of the acetifier must be controlled by regulating the air supply, through partly closing or opening the air holes at the base, and the rate at which liquor is supplied through the distributor. The temperature should be maintained at about 95° F. (optimum) and although temperatures exceeding 100° F. are easily attained, and speed up the process, loss of alcohol is great, both on account of evaporation and over-oxidation to carbon dioxide. When efficiently operated the conversion of alcohol to acetic acid should be 90 to 95 per cent. of the theoretical. Efficiency below this means excessive air supply.

The vinegar obtained after being put through the acetifier three or four times usually contained 5 to 6 per cent. acetic acid, depending upon the original alcoholic content of the liquor. By adding further quantities of alcohol, acetic acid contents up to 10 per cent. could be obtained.

The addition of small quantities of nutrients (Nitrogen, Potash, Phosphate) did not appreciably affect the rate of acetification. From the analysis figures it is apparent that the juices carry with them a sufficiency of nutrients left over from the alcoholic fermentation stage.

It may be noted that whilst cane juices were used in the above experiments, the process has yielded equally satisfactory results with solutions made from cane molasses, &c. A solution of 15 to 20 Brix is made, fermented with yeast and subsequently acetified as above. The same yeast,

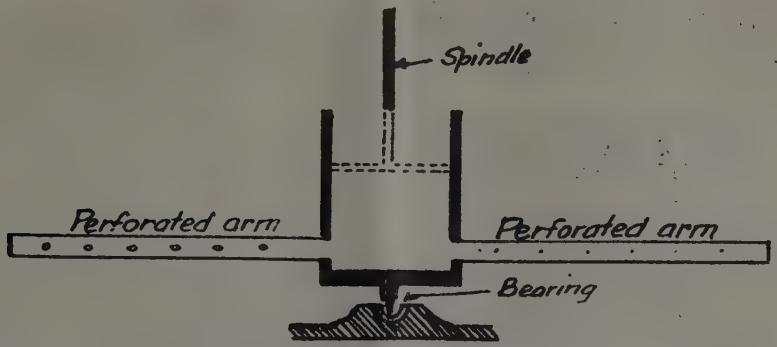

Fig. 1 – Section of SPARGE

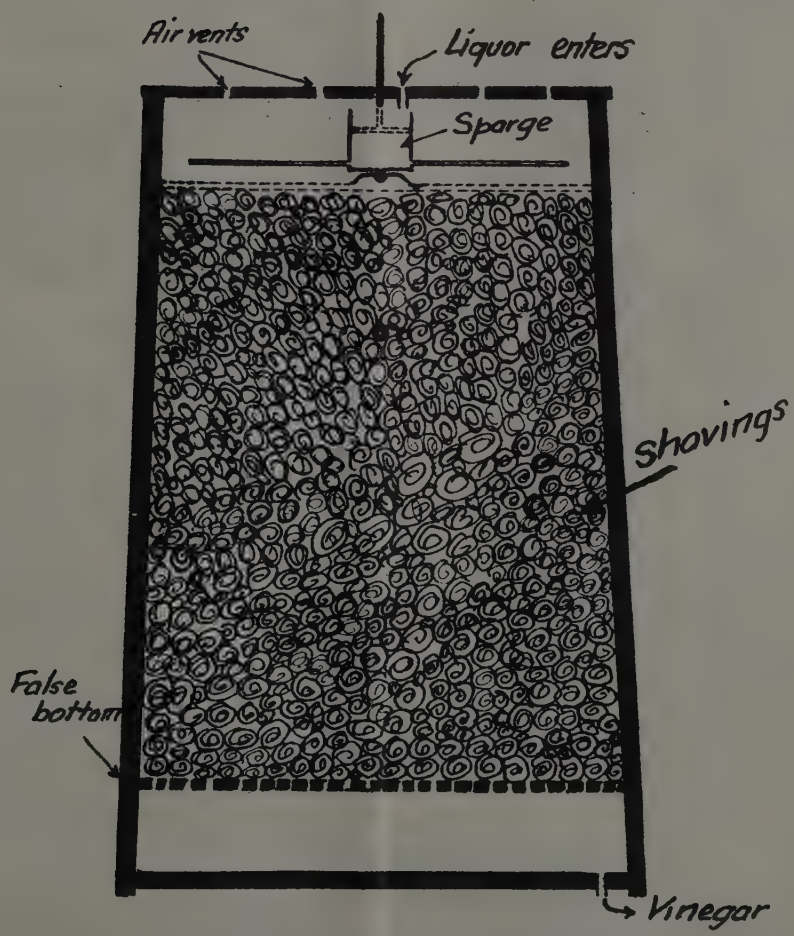

Fig II – Section of GENERATOR

however, does not give the same yields or rates of fermentation with different sugar solutions, and a type most suitable for each solution should therefore be developed.

Vinegar Production on a Large Scale.

The further study of vinegar production on a large scale was made by the author in Canada recently. In the light of the experience gained on the construction and actual operation of commercial generators, it became apparent, that whilst the principles and methods of operation already detailed were fundamentally sound, the actual construction of the acetifier could be modified with advantage.

The chief features to which attention may be drawn are as follows. The type of generator employed in the experiment just described was made square in section in anticipation of regular easy cleaning. The type commonly used in practice is almost cylindrical in shape, being slightly wider at the base than at the top. It can be made from wood plank (*e.g.*, pitch pine two inches thick) by any experienced cooper. It is much cheaper to construct, and can much more easily be made water tight. It further permits a more uniform distribution of liquor and air and prevents stagnation, with consequent contamination which is most likely to occur in corners.

The type of filling is an important consideration, regulating as it does the frequency of renewal through clogging, &c. Operating experience suggests the retention of beech shavings as the most successful type of filler. It is primarily the natural curl which this material takes on, as well as their freedom from noxious oils, tannin, &c., that make them the most serviceable type of filler. Quite satisfactory results are, however, obtained by the use of other shavings (*e.g.*, those of deal) which have been first thoroughly soaked in hot water.

The distribution of the fermented liquor in large scale operation takes place by means of a revolving "sparge" (Fig. I) instead of by wicks. The sparge revolves by the gravity and outflow of the liquor and resembles a rotating garden spray—it is of very simple construction and functions well without much attention to clogging, &c. It may be turned from a piece of hardwood, the arms being made of reed or hard rubber with perforated holes in opposite directions. The spindle is supported in some form of glass cup which functions as a bearing and the whole fixed just above the surface of the shavings. A speed of about 90 to 120 revolutions per minute is maintained by the rate at which liquor is admitted.

The top of the generator is securely covered, the spindle of the sparge passing through a hole cut in the centre. Four holes about two inches in diameter are also cut in the top and the rate at which air passes through the generator may be regulated by opening or partially closing these holes. The method of operating is exactly similar to that employed in the experimental generator described above.

Quick vinegar production on a large scale depends mainly on the size of generators, as the larger these are the more smoothly and efficiently they run. Small generators have low efficiency, and in the absence of experienced and rigid attention can easily get out of control. They clog readily and are very easily contaminated. The commercial production of vinegar in small units is therefore inadvisable. Generators of seven to ten feet diameter and 12 to 15 feet high, capable of producing 6,000 to 10,000 gallons of vinegar monthly are usual; these function with around 95 per cent. efficiency and, when filled with beech shavings, will run for two and a half years without renewal of packing. Fig. 2, shows the arrangement of a typical commercial generator.

The strength of vinegar produced from commercial generators is usually around five per cent. acetic acid—depending on the original alcoholic content of the liquor. It is relatively free from "mother" and could be utilised directly for syrup manufacture. For domestic use the vinegars are usually aged in large wooden vats to improve flavour, &c.

Vinegar should be handled and stored only in wooden receptacles and never in iron ones. Thus, in the construction of generators, no iron nails must be used. Copper nails, on the other hand, will withstand the action of vinegar, while brass pumps can be utilised for pumping the liquors directly; compressed air may be used with advantage. Pipe lines, &c., are of hard rubber which can be threaded and fitted as usual.

Summary.

1. The acid inversion of sucrose in the manufacture of syrups from sugar-cane juices. The advantages of using acetic acid for the inversion and the need for a steady uniform supply of acid from the cane juice.

2. The fermentation of the cane juice as the first step in vinegar production. The selection of pure culture yeasts for rapid fermentation and the determination of the factors—effects of nutrients, temperature, hydrogen ion concentration—for optimum growth of such yeasts.

3. The acetification of the fermented juices; the selection and propagation of acetic bacteria and the optimum conditions for their development. Construction of an experimental acetifier or generator; details of its filling and operation.

4. Quick vinegar production on a large scale. The type of acetifier employed, with details of construction and operation. The nature, quality and quantity of vinegar produced; methods of handling storage, &c.

References.

(1) Mitchell—Vinegar Manufacture, p. 199.
(2) Hansen—Practical studies in fermentation.
(3) Fowler—Bacteria and Enzyme Chemistry, p. 32.
(4) Janke—Ann. Brass. et Distill. 1921, 69, 86.
(5) Bureau of Chemistry, U. S. Dept. of Agric. *J. Ind. and Eng. Chem.* Vol. I, p. 260.

THE CACAO INDUSTRY OF TRINIDAD.

SOME ECONOMIC ASPECTS.

Part II.

General History of the Production and Consumption of Cacao.

By C. Y. Shephard.

[*Author's Note: The following article is intended to serve as a general background for a more detailed discussion of the historical development of the Trinidad cacao industry. It does not pretend to be in any way exhaustive, and, for a fuller treatment of the subject, the reader is referred to "The Cocoa and Chocolate Industry", by Knapp, and "Cocoa: World Production and Trade", E.M.B. No. 27. As copies of the "Gordian" are available for only a few years, the statistics quoted, which were obtained from a wide variety of sources, have proved irreconcilable. The errors thus introduced are unlikely to affect the deductions, which are of a very general nature.*]

Cacao was unknown to Europeans until the beginning of the sixteenth century. There is little doubt, however, that it had been grown in tropical America for many centuries before this (5), as it played an important rôle in the popular traditions and legends of the Indians of Mexico. In fact, at the time when Europeans first visited the New World the cultivation of the tree was so widespread that its original home must remain a matter of conjecture, though it is generally believed to have been located in the basins of the Orinoco and the Amazon (3). That the Mexicans held cacao in high esteem is indicated by their legend that the plant was of divine origin. The beans served the Indians not only as a beverage but also as a medium of exchange, for it was the custom of the various provinces of Mexico to pay tribute to their chief in the form of cacao (5). Although it is impossible to translate the value of cacao in terms of present day currency, the fact that a rabbit could be purchased for ten, and a slave for 100 beans (5) (7), suggests that the price was extremely high.

The drinking chocolate of those days was quite different from that of to-day, for it was prepared by boiling a mixture of ground corn and cacao, flavoured with red pepper (5). Montezuma, the 'Emperor' of Mexico, is reputed to have consumed enormous quantities of this beverage, and, when he was defeated by the Spaniards, large stores of beans were discovered in his palaces (8) (2). The Spaniards were not impressed with this drink, for it contained no sugar*, and at first they regarded their discovery as of no commercial significance (8). When some nuns of Guanaca began to mix sugar, vanilla and cinnamon with the cacao beans, the Spaniards found the beverage far more agreeable, and by the beginning of the seventeenth century chocolate had become popular among the Spaniards in America. The method of preparation was kept a close secret, and drinking chocolate was first exported to Spain only in the form of cakes. Eventually, however, the secret leaked out and Spain began to import the raw bean (5). This knowledge was not immediately shared by other Europeans, for it is recorded that some Dutch sailors, who found a quantity of cacao on the Spanish ships they had captured, threw the beans overboard to the accompaniment of scornful epithets (7) (11).

The process of manufacture gradually became known throughout Europe, and became the subject of special treatises. Colmenero's book on Chocolate, which was published in Madrid in 1631, was afterwards translated into several European languages, and became the standard work of the century. His recipe indicates the nature of chocolate as consumed during the seventeenth century. "Take a hundred cacao kernels (that is, about a quarter of a pound), two heads of chili or long peppers, a handful of anise of orjevala, and two of mesachusil or vanilla—or instead six Alexandria roses, powdered—two drachms of cinnamon, a dozen almonds, and as many hazelnuts, a half-pound of white sugar, and anotto enough to colour it, and you have the king of chocolates" (8). This heavy concoction became a fashionable and costly novelty, and was frequently taken at Oxford in 1650. Chocolate houses were opened in London and Amsterdam, and began to replace coffee houses as the resort of the 'elegant and refined' (7). According to an announcement in the *Public Advertiser* of 1657, the first house in London was opened in Bishopsgate Street, Queen's Head Alley (7). Others, such as 'White's Chocolate House' and the 'Cocoa Tree', developed into famous clubs. Like tea and coffee, chocolate experienced the complete gamut of literary criticism; some praised it lavishly as food fit for gods, while others, equally emphatic, condemned it as a violent inflamer of the passions (8). In spite, or perhaps because, of this wordy warfare, by the end of the seventeenth century the consumption of chocolate was no longer confined to wealthy epicures and cranks, who regarded it mainly as a physic, but was widely appreciated as a beverage (8). Its high cost, which was between 10*s.* and 15*s.* a pound, together with its rich nature, alone prevented it from becoming universally popular (8).

At the beginning of the eighteenth century Venezuela was the principal producer of cacao, though the cultivation had spread to a number of the West Indian Islands. Spain endeavoured to maintain a monopoly of the raw material by

* The sugar-cane was then unknown to the inhabitants of Mexico.

prohibiting export to any other country, but between 1706 and 1722 not a single Spanish vessel sailed from Venezuela to Spain, and the bulk of the cacao went to Amsterdam. From 1728 to 1780 the cacao trade of Venezuela was controlled by a company of noblemen of Biscay, who obtained an exclusive licence from Philip V (5). Nevertheless, appreciable quantities of cacao entered international trade, either as the result of illicit trafficking, or from other sources of supply. During this century England began to manufacture her own drinking chocolate, and, of the many small works then established, that founded by Dr. Joseph Fry, in 1728, survives to this day. Substantial reductions were made in the price of chocolate; thus, in 1730, chocolate produced by Walter Churchman's patented process, was sold at 5*s*. a lb. if plain, and 6*s*. a lb. if mixed with vanilla. Originally the entire preparation was performed by hand, and Dr. Fry was the first, in England, to instal a watermill for grinding the beans. In 1795 Messrs. Fry installed one of the recently developed steam engines, the first in Bristol, for what the chroniclers of the time described as "the trifling object of grinding chocolate" (8). Though cheaper raw material and improved methods of manufacture reduced the price of chocolate, the industry was still hampered by high duties. In England, for example, *The Humble Memorial of Joseph Fry* (1776), complained that, not only did cacao beans pay 10*s*. a cwt. duty, but the chocolate obtained from them was also taxed 2*s*. 3*d*. a lb. In consequence the importation of raw cacao into Great Britain did not exceed 100 tons by the end of the eighteenth century (7).

The nineteenth century witnessed a steady expansion of the industry. One of the prime causes of this development was the invention of a method of preparing cocoa powder, by a Dutch manufacturer, C. J. van Houten, in 1828. The cacao bean contains about 50 per cent. of cacao-butter, and, as a result, chocolate prepared from the whole bean was a nourishing, but extremely rich and heavy, beverage. It was customary to reduce this fatty richness by mixing some farinaceous material with the cacao beans. Unfortunately cereal products were often added in excessive quantities on account of their relative cheapness. By van Houten's process a great part of the fat was expressed, thus leaving a cocoa powder giving a lighter and more pleasant beverage, which gradually replaced the old fashioned chocolate cakes. The cacao-butter, which was expressed, was then regarded as a by-product of very little value. This process does not appear to have been adopted in England until 1866, when Cadbury Bros. introduced their "Cocoa Essence" (8).

The existence of large quantities of cheap cacao-butter made it possible to introduce eating chocolate. Unless chocolate contains about 25 per cent. of cacao-butter it cannot be moulded. A mixture of equal amounts of sugar and cacao beans would provide the necessary proportion of cacao-butter, but would result in a chocolate too bitter to suit the public taste. By replacing a portion of the cacao beans by cacao-butter a more palatable eating chocolate can be obtained. Although a comparatively modern process the exact date of its introduction is unknown, but eating chocolate was sold by Fry & Sons in 1847, and by Cadbury Bros. in 1849. The invention of milk chocolate* further stimulated the demand for cacao-butter. It was first produced on a commercial scale in the closing years of the nineteenth century by Daniel Peter, of Vevey, Switzerland, who invented his process in 1876 (8).

Other improvements helped to increase the popularity of cacao products. The smooth, velvety "fondant" chocolate has now taken the place of the old coarsely ground variety. This chocolate differs from the hard, dry, chocolate, in containing a larger proportion of cacao-butter, and in having the chocolate mass refined to a much greater degree, both of which help to render it smooth to the palate. The demand for cacao has been further enhanced by its property of blending with most flavours, and, in the form of an "overcoat" or coating, of protecting and preserving the confection inside. The preparation of covering chocolate is similar to that of plain chocolate, except that an even greater proportion of cacao-butter is added to render it sufficiently limpid to secure an even and thin coating (11).

These inventions, besides stimulating a rapid expansion in the general demand for cacao products, have also changed the relative values of cacao-butter and cocoa powder. At first cacao-butter was a mere by-product of cocoa powder, and was worth little, but, as the consumption of chocolate increased, its value rose. Before the Great War the amount of cacao-butter expressed for the production of cocoa powder was just sufficient to meet the requirements for chocolate. Subsequently the consumption of chocolate expanded to such an extent that cacao-butter has become the more valuable product, and many tons of cacao beans are now used primarily for their cacao-butter (8).

These improvements in manufacture enabled cacao products to be retailed at lower prices. The decline of Spanish power in tropical America released additional supplies of raw material, but heavy duties still hampered demand. Thus, at the beginning of the nineteenth century, the duty on cacao entering Great Britain from British Possessions was £10 5*s*. 4*d*. per cwt., and from foreign countries £32 13*s*. 4*d*. per cwt., while an additional £1 3*s*. 4*d*. per cwt. was levied on the finished product for home consumption. These duties were gradually reduced until, in 1853, both British and foreign cacao paid only 9*s*. 4*d*. per cwt. (7), and for more than 60 years the duty was stabilised at this rate. During the Great War the duty rapidly rose, and by 1916,

*Sir Hans Sloane, surgeon to George II, is believed to have been the first individual to produce small quantities of a solid confection combining milk and chocolate.

had reached £2 16s. 0d. per cwt. In 1919 the preference on British cacao was re-introduced, the Colonies paying £1 15s. 0d., and foreign countries £2 2s. 0d., respectively, per cwt. Since 1924 the preferential rate has remained at 11s. 8d. per cwt., and the general rate at 14s. per cwt. (8). In the United States of America and Holland, two of the most important consumers, cacao is admitted free of duty.

Table II.

Import Duties on Raw Cacao in shillings per cwt.* (3).

Country.	*General.*	*Preferential.*
	s. d.	s. d.
U.S.A.	Free	Free
Germany	17 5	17 5
United Kingdom	14 0	11 8
Holland	Free	Free
France †	14 10	Free

Substantial reductions in prices resulted, and cacao products were thereby brought within the means of a large section of the general public.

Within the past 40 years there has been an enormous increase in the consumption of cacao. In 1806 Humboldt estimated that the entire European consumption of cacao was less than 10,000 tons, of which Spain consumed nearly one-half (6). A period of steady expansion followed, but, even by 1830, the consumption in Great Britain and Ireland amounted to little more than 400 tons, of which more than half was absorbed by the Navy (7). By 1895 the total consumption of cacao had reached 76,000 tons. During the next 30 years consumption was so rapidly accelerated that, by 1924, the total exceeded 480,000 tons (1).

This enormous increase in production has been accomplished by the rise of new producers, and accompanied by the decline of old producers. This may be illustrated by following the practice of the *Gordian* in dividing the cacao producing countries of the world into two classes, namely, those growing 'fine' types of cacao, such as Trinidad, Ecuador, and Venezuela, and those growing 'ordinary' types, of which the Gold Coast, Brazil, Nigeria, the Ivory Coast, Santo Domingo, and San Thomé, are the most important.‡ In 1895 'fine' types accounted for four-fifths of the total, Ecuador being by far the most important producer, while the exports of the Gold Coast and Nigeria were negligible, being 13, and 22, tons, respectively. During the next 25 years the export of both types expanded, but the rate was so much more rapid in the case of 'ordinary' types that, by 1920, the export of this type represented two-thirds of the total. This change was due, primarily, to the amazing development of the Gold Coast cacao industry, for, in 1920, her export of 127,000 tons, exceeded the total export of 'fine' types, and accounted for no less than one-third of the world's total export. This difference became even more accentuated during the next ten years for, while the exports of 'ordinary' types rose from 264,000 tons to 390,000 tons, the exports of 'fine' types declined from 113,000 tons to 89,000 tons. Thus, in 1930 'ordinary' types accounted for four-fifths of the world's total, and 'fine' types for only one-fifth. In brief, within 35 years the relative importance of 'fine' and 'ordinary' types has been completely reversed.

Throughout this period, however, 'fine' cacao has enjoyed a substantial premium in price. This premium is due to two factors: the superior variety of cacao grown, and the better methods of preparation.* It is now seriously suggested that the products of 'ordinary' cacao are so satisfactory to public taste, that "the old distinctions in quality between cacaos have ceased to exist, and only the external differences of appearance remain" (2). This is a matter of serious consequence to the producers of 'fine' types, for it might be assumed that, once the prejudice of the market in favour of external appearance had been overcome, the premium for 'fine' cacao would disappear. In fact, a recent publication, comparing the prices of Accras and Trinidad cacaos, attempted to demonstrate that, between 1924 and 1928, there actually was "a significant narrowing of the margin between the two kinds which may be taken as typifying respectively 'ordinary' and 'fine' cocoa" (3). Quotations for 1924 and 1925 showed that Accras realised only about 60 per cent. of the price of Trinidad 'fine' cacao, whereas in 1927 and 1928 Accras realised 87 and 86 per cent., respectively, of the price of Trinidad cacao. The period selected can hardly be regarded as satisfactory, since the premium for 1924 was exceptionally high, and that for 1928 exceptionally low. If the period is extended it will be observed that from 1918 to 1931 there were wild fluctuations both in prices and the premiums, and there is no conclusive evidence that the years 1927 and 1928 mark the beginning of a new trend. In fact, had the period 1927 to 1931 been selected, it might have been demonstrated, with equal force, that there had been a significant widening of the margin between the two kinds.

* These figures do not take into consideration recent changes in the rates of exchange.

† For some colonies a quota is fixed. All imports also pay 9s. 11d. per cwt. internal tax, and two per cent. (of duty paid value) turnover tax (3).

‡ It should not be assumed that all 'fine' types are well prepared, and that all 'ordinary' types are badly prepared. Appreciable quantities of Trinidad cacao are unfermented and ill-prepared, while a small, but increasing, proportion of the exports from the Gold Coast and Nigeria is properly fermented and well-prepared.

* The variety of cacao grown is the principal factor distinguishing the producers of 'fine', and 'ordinary' cacaos. The range of quality within each group is very great, and cacaos from Ceylon, Ecuador and Venezuela, for example, obtain a substantial premium over Trinidad cacao. The two groups merge into one another and there is little to distinguish the best types grown by producers of 'ordinary' cacao from the worst types grown by producers of 'fine' cacao.

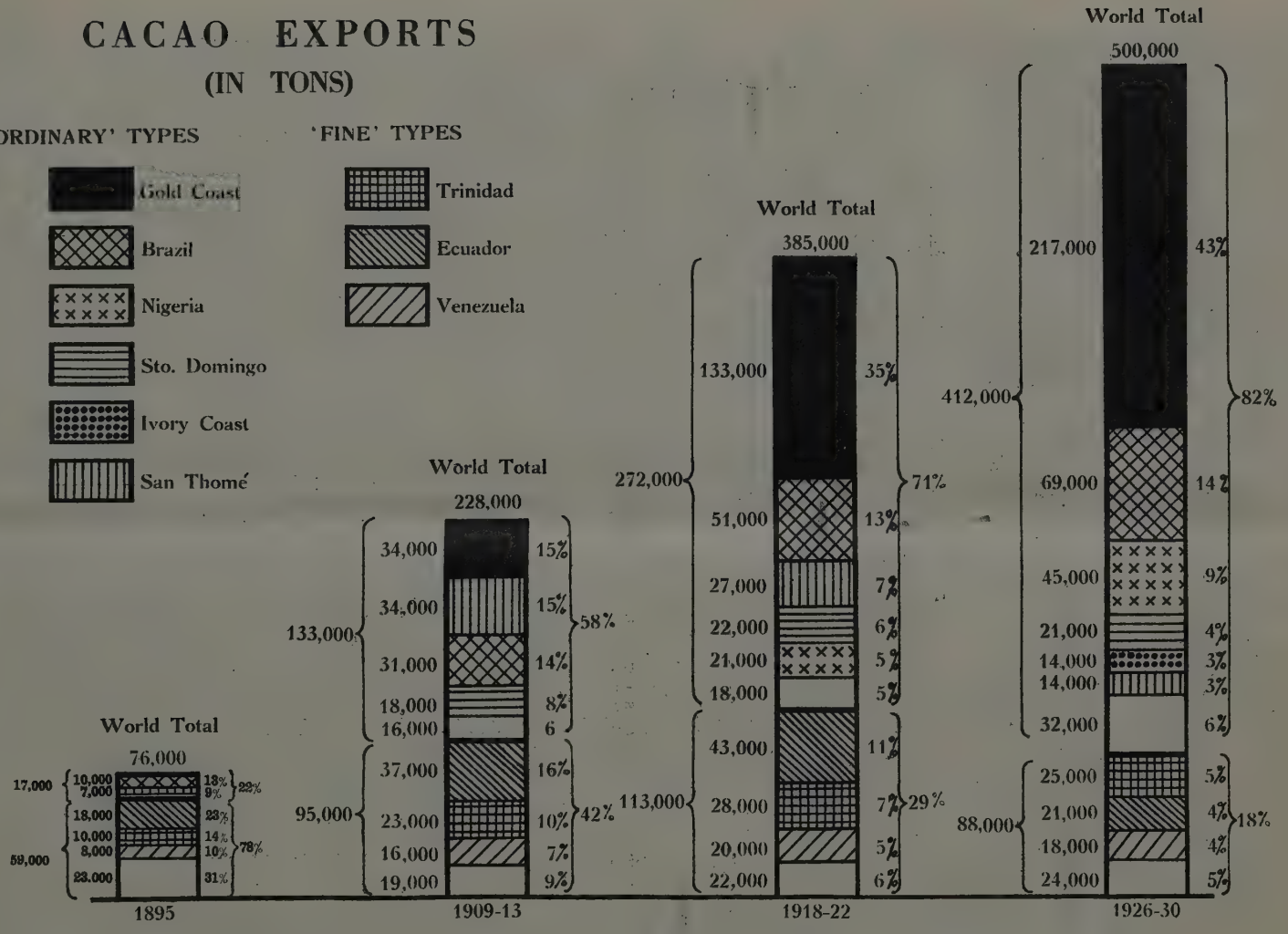

Fig II.—Showing the growth of Cacao exports and the relative importance of 'Fine' and 'Ordinary' types of Cacao.

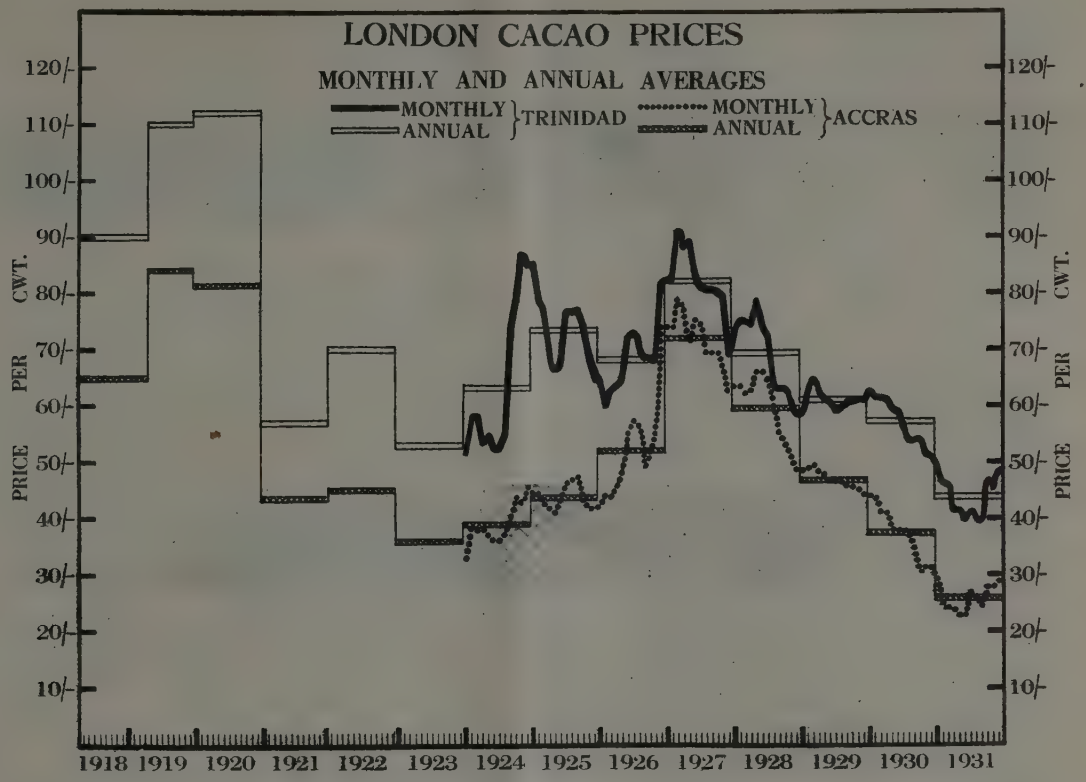

Fig. III.—Showing the Relation between the prices of Trinidad ('Fine') and Gold Coast ('Ordinary') cacaos.

Table III.

Relation between the Average Annual Prices of Gold Coast and Trinidad Cacao * (12) 1918-9—1931.

Year.	*Price per cwt.*				
	Trinidad		*Gold Coast.*		
	s.	*d.*	*s.*	*d.*	*% of Trinidad price.*
1918-19	90	0	65	0	72.2
1919	110	0	84	0	76.4
1920	112	0	81	6	72.8
1921	57	0	43	6	76.3
1922	70	0	45	0	64.3
1923	53	0	36	0	67.9
1924	63	4	38	11	61.5
1925	73	6	43	10	59.6
1926	68	2	52	2	76.5
1927	82	4	71	11	87.3
1928	69	2	59	7	86.1
1929	60	11	46	10	76.9
1930	57	2	37	5	65.5
1931	43	10	25	11	59.1

* Quotations kindly supplied by Messrs. Woodhouse, Carey & Browne.

The sweeping statement that "the old distinctions in quality between cocoas have ceased to exist", is largely robbed of its force by the qualification that, the "use of high-class cocoas is confined to very high-class cocoa and chocolate" (2). This clearly indicates that there still remains a difference between the two types, for manufacturers would not continue to pay a premium for 'fine' types if as good a product could be manufactured from the 'ordinary' types. It would appear that the future of 'fine' types is bound up with that of high-class cocoa and chocolate. This presents an extraordinary contrast with 35 years ago, when 'fine' types formed the basis of practically all cocoas and chocolates. Nevertheless, even if the demand for high-class cocoa and chocolate shows no appreciable expansion it may be expected that the premium for 'fine' cacaos will be maintained, for the production of 'fine' types is definitely declining. It is essential that producers of 'fine' types should make every effort to maintain as wide a margin as possible between the quality and appearance of the two types. Definite improvements have been made in the preparation of 'ordinary' types, and it is probable that the portion of the premium due to the superior

preparation and appearance of 'fine' types will eventually disappear. Any relaxation on the part of the producers of 'fine' types in the preparation of their cacao will hasten this event. The writer believes that 'fine' types properly prepared, will always command a premium over the 'ordinary' types, on account of the superior quality of the bean. When the price for 'ordinary' cacao is high the margin is likely to be relatively (though not absolutely) smaller than when the price of 'ordinary' cacao is low. There is no evidence to support the common belief that the margin must inevitably diminish and eventually disappear.

It is certain that few individual producers of 'fine' types can hope to produce at prices which would be remunerative for producers of 'ordinary' cacao. In short, the maintenance of the premium is vital to producers of 'fine' types. This is not necessarily due, as is so often assumed, to the peasant being a more efficient producer than the individual, or company, owning a large estate. The 'over-head charges' of an estate do not necessarily represent an additional burden from which the peasant proprietor is exempt. They are incurred with the object, frequently realised, of securing other and superior economies. It should be borne in mind that nearly one-half of the total area under cacao in Trinidad is owned by peasants. Although only meagre information is available of the economic condition of these small-holders, there is no evidence to suggest that they have escaped the incidence of the present depression.

It is submitted that the important distinction between the producers of 'ordinary' and 'fine' types lies, not between small-holding and the estate, but in the average age of the properties. In most of the countries producing 'fine' types the cacao industry has existed for at least a century. On the other hand, in most of the countries producing 'ordinary' types the properties are 'young,' and have developed within the past 30 years. If, however, the situation is examined more closely, it will be observed that most of the properties in the so-called 'old' producing countries have been established within the past 50 or 60 years. This embraces the period of development in San Thomé, which alone, among important producers of 'ordinary' types, has experienced a serious decline in production. In other words the average ages of the properties in 'old' and 'young' producing countries differ by periods of only 20 to 30 years. Reasons will be advanced for suggesting that the 'economic life' of a cacao estate is much shorter than is generally supposed, and that the production of cacao can be maintained only by the repeated development of new areas. In any individual country the problem becomes important only after all available areas of land have been developed. Lack of detailed information regarding planted acreage makes it impossible to examine this particular subject in a more conclusive manner. Some areas, of course, remain profitable long after others have been abandoned. It is proposed to examine this problem in more detail in regard to Trinidad, and to submit evidence that, after certain ages, which are determined by a variety of factors, yields tend to decline, and unit costs of production to rise. This problem is of the utmost importance, not only to 'old', but also to 'young', producers.

These changes in production have been accompanied by a notable increase in the importance of the British Empire as a producer of cacao. In 1895 her production amounted to 17,000 tons, or about one-fifth of the world's total. This production consisted almost entirely of 'fine' types of cacao, of which she produced one-quarter of the world's total. During 1926 to 1930 her production averaged 300,000 tons, and her proportion of the world's total output had risen to sixty per cent. The increase has been more notable in the 'ordinary' types, of which she now produces more than three-fifths, due to the extraordinary rise in production of the Gold Coast, supplemented by a rapidly expanding output from Nigeria. In spite of a tendency for her exports of 'fine' types to decline, her proportion of the world's total has risen to more than two-fifths. In the Gold Coast and Trinidad she embraces the largest producers of 'ordinary' and 'fine' types of cacao.

The imports of raw cacao by British countries have also increased, but by no means to the same extent. Thus, during the five years 1926 to 1930 they imported an annual average of 71,000 tons, compared with 30,000 tons during 1909 to 1913. Most of this cacao is taken by the United Kingdom which took an annual average of 57,000 tons from 1926 to 1930, compared with 27,000 tons from 1909 to 1913. The origin of the imports of raw cacao into the United Kingdom has shown a remarkable change. From 1909 to 1913 slightly more than half her imports of raw cacao came from British producers. In 1919 a preference on British cacao was re-introduced, and, from 1926 to 1930, she obtained 94 per cent. of her imports of raw cacao from within the British Empire. It is only in 'ordinary' types that her imports of British cacao have risen. Thus, in 1929 she imported 69,000 tons from British West Africa, compared with 9,000 tons in 1913. Her imports of 'fine' cacao from the British West Indies, despite the preference, have shown a marked decline, being little more than half the quantity taken in 1913. Yet her recent imports of cacao from Venezuela show an appreciable rise compared with the period immediately preceding the Great War. The small imports of 'fine' types into the United Kingdom are confined to the choicest grades. Trinidad produces small quantities of the choicest quality cacao, and the Cocoa Planters' Association has recently shown that, when this cacao is graded and marketed separately, it

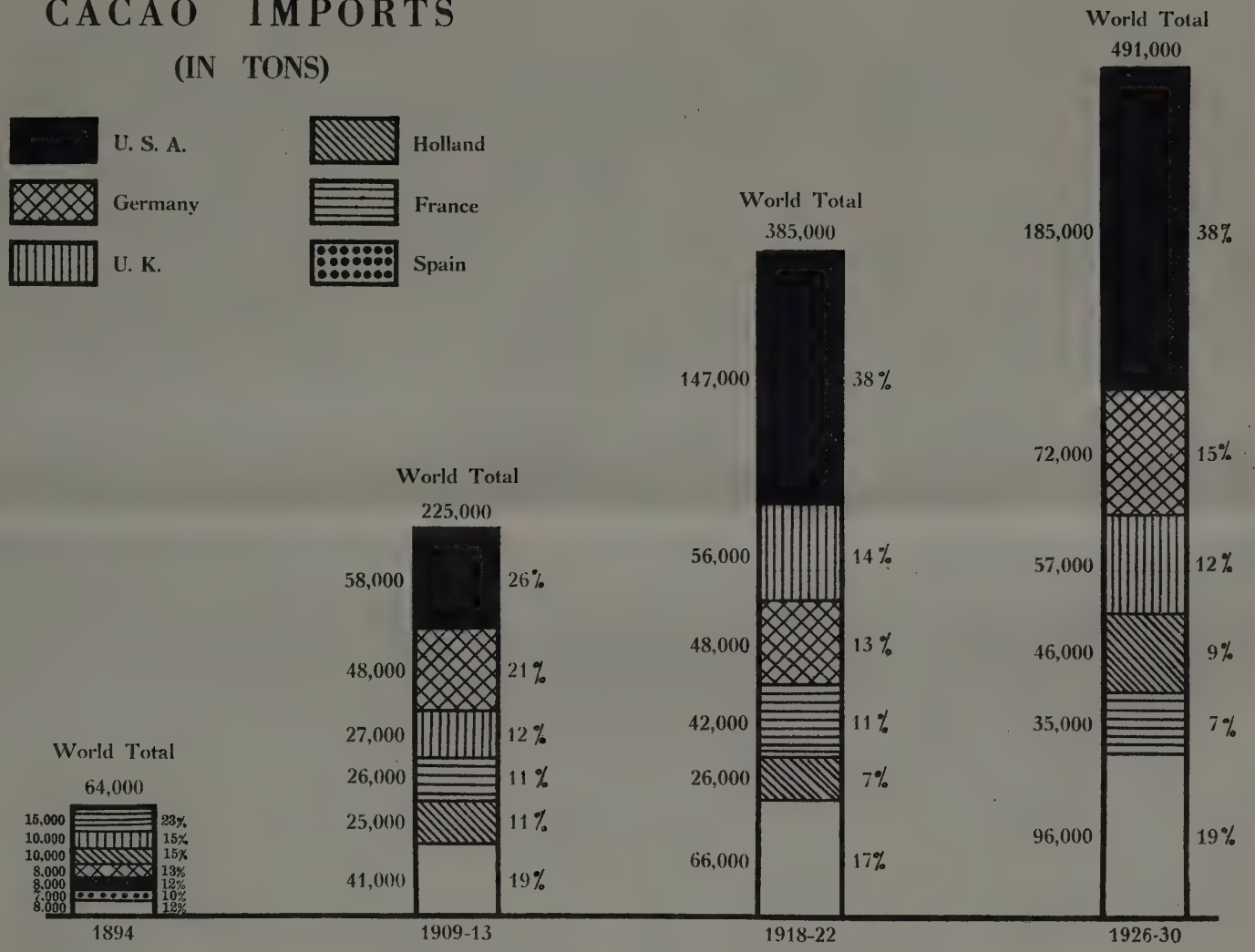

Fig. IV.—Showing the growth of Cacao Imports and the relative importance of the principal Importers.

commands a substantial premium in price over good plantation cacao (9). The definite decline which is taking place in the production of choice cacao from foreign countries, affords Trinidad an opportunity of meeting a large portion of the United Kingdom's requirements of this particular quality, provided that the quality is rigidly maintained by grading.

Important changes have taken place in other consuming countries. Spain originally held a monopoly of the cacao market, and still remained the largest importer at the begining of the nineteenth century. By 1885 France had become the principal purchaser, the United Kingdom being next in importance. Both countries subsequently declined in relative importance, and before the end of the nineteenth century the U.S.A. took the lead, which she has consolidated, in a striking manner, during the twentieth century. During the five years 1926 to 1930 she imported annually an average of 185,000 tons of cacao, equivalent to nearly forty per cent. of the total imported by all countries. The enormous importance of the U.S.A. market may be illustrated by the fact that her average annual imports during this period considerably exceeded the combined imports of her three nearest rivals, Germany (72,000 tons), the United Kingdom (57,000 tons), and Holland (46,000 tons). France declined in relative importance to fifth place with an average import of 35,000 tons, while Spain next in importance, and once the dominating factor in the cacao market, imported only 9,000 tons. Thus five countries alone import 395,000 tons, or more than eighty per cent. of the world's total.

It is of interest to note that most of the principal manufacturing countries have increased their exports of cacao products. In addition, other countries are now developing cacao and chocolate industries for their domestic markets, and it is probable that these importers of raw cacao, at present unimportant, will exert greater influence on the market in the course of time. At present, however, nearly ninety per cent. of the total imports of cacao are taken by Europe and North America. Of these Europe is by far the more important, taking an annual average of 280,000 tons, or sixty per cent. of the total, compared with 195,000 tons for North America. The annual aggregate imports into all other continents averaged less than 20,000 tons. Yet even in the U.S.A. the imports of raw cacao amount to only 3 lb. per head per annum, or one ounce per week. The increase of cigarette smoking by women, the greater consumption of fruit, the development of the soda-fountain, ice-cream and fruit syrup businesses, have tended to check the rate of increase in the consumption of cacao products (3). There can be little doubt of the world's capacity to absorb larger quantities of cacao and the experience of other industries suggests that demand could be stimulated by a comprehensive scheme of advertising, financed jointly by the manufacturers and growers (10). This possibility has already been explored, but financial stress, among important producers, has prevented the immediate realisation of the project.

It is probable that both production and consumption will show substantial increases, but the outlook is complicated by such a large number of obscure factors that it is impossible to give any clear indication of the future trend of prices. It may be presumed, however, that the level will be higher than at present, for the maintenance of the existing unprofitable prices would result in the disappearance of large areas under both peasant and estate cultivation. The more immediate outlook is promising, for cacao is in an extremely strong statistical position. At present, prices are influenced more by the world-wide depression than by factors peculiar to the cacao industry, and it may be expected that any improvement in the general financial situation will react in a particularly favourable manner on cacao prices. Nevertheless it is unlikely that a high price level, corresponding to that of before the Great War, will be maintained, for large areas still await development. It is probable that prices will fluctuate between profitable and unprofitable levels, and it is essential that existing producers should seek to modify their organisation in ways which will tend to reduce costs of production, and introduce a measure of greater financial stability. In Trinidad the scientific aspects are being studied by the Department of Agriculture, and the Cacao Research Officers of the Imperial College of Tropical Agriculture. In the present series of articles a number of economic aspects will be examined, and it is believed that the results will prove of importance not only to Trinidad, in which country the investigations were carried out, but also to other cacao producing countries.

Literature.

1. Aspinall, Sir A. E. —Handbook of the B. W. I., B.G. and B.H., 1929-30. — *West India Committee*, 1929.
2. Cadbury, John—Paper read at the Inter. Col. Agric. Congress in Paris; quoted by *Tropical Life*, 27th year, No. 315.
3. Empire Marketing Board — Cocoa. World Production and Trade. E.M.B., No. 27, May 1930. *H.M.S.O.*
4. *Gordian, The*—Vols. 30-37. Hamburg.
5. van Hall, C. J. J.—Cocoa. *Macmillan*, 1914.
6. Hart, J. H.—Cocoa. *Duckworth & Co.*, 1911.
7. Historicus.—Cocoa. All about it. *Sampson Low, Marston & Co.*, 1896.
8. Knapp, A. W.—The Cocoa and Chocolate Industry. *Sir Isaac Pitman*, 1930.
9. Shephard, C. Y.—Cocoa Planters' Association. *Tropical Agriculture*, Vol. VII, No. 11, and Vol. VIII, No. 12, Trinidad.
10. Shephard, C. Y.—A Cocoa Planters' Association. *Tropical Agriculture*, Vol. II, No. 2, Trinidad.
11. Whymper, R.—Cocoa and Chocolate. Their Chemistry and Manufacture. *J. & A. Churchill*, 1921.
12. *Woodhouse, Carey & Browne's Fortnightly Reports.*—Mincing Lane, London.
13. Wright, H. — Cocoa. *A. M. & J. Ferguson*, Ceylon, 1907.

MANURIAL EXPERIMENTS WITH SUGAR-CANE.

I.—Burying *versus* Non-burying of Sulphate of Ammonia in Relation to its Effect on the Yield of First Ratoon Canes.

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[*This paper was read at the Fourth International Congress of Sugar-Cane Technologists held in Porto Rico in March*, 1932 (6).]

I.—Introduction.

The aims of the experiments described in this paper are two-fold :—

Aim (1).—To determine the effect on yield of sugar-cane (B.H. 10/12, first ratoons) of an application of 3 cwts. of sulphate of ammonia to the acre.

Aim (2).—To compare the results given by this dressing when buried with those obtained when it is left uncovered on the soil surface.

Aim (1).

Previous to a series of manurial experiments which were begun in 1927 the evidence with regard to the effect of sulphate of ammonia on the yield of sugar-cane in Trinidad was conflicting, and, on the whole, adverse to its use. This evidence was based on a number of trials laid out in the old style, *i.e.*, replicates of each treatment were included, but the plots were arranged in regular order rather than in positions determined by random choice.

The experiment outlined below was laid out in the form of a series of Latin Squares, in 1927, on the land of the Ste. Madeleine Sugar Company. It is probably the first manurial experiment set up in the West Indies in a manner such that Fisher's "Analysis of Variance"(2) can validly be used for the examination of the yield data obtained. For this reason alone it is worthy to be placed on record. In addition, for the first time in Trinidad, it gave conclusive evidence as to the value of sulphate of ammonia as a manure for sugar-cane.

Aim (2).

In countries in which sugar-cane is a staple crop considerable difference of opinion exists as to whether it is advantageous to cover with earth the dressing of sulphate of ammonia. Earle (1) and Quintus (3), for example, are strongly in favour of burying the manure.

According to Earle (p. 240, *loc. cit.*) :—

"With ratoon fields the only proper time to apply fertiliser is when the cane is first off-barred, as soon as possible after lining the trash. This gets it down fairly deep, where it will be well covered by the soil in subsequent cultivations. The method current in some districts of throwing the fertiliser on top of the ground and trusting to its later being covered with hoes, is very wasteful, and the cane never gives best results or full value for money expended."

Quintus states (p. 101, *loc. cit.*) :—

"It is recommended to administer sulphate of ammonia in manure holes and not to scatter it in the furrow, because experiments in which the two methods were compared told directly in favour of the manure holes. This may be clearly explained in this way. The sulphate of ammonia which is scattered will, during the ensuing watering be at once and entirely absorbed by the thin top layer, as clay firmly fixes the ammonium ion. This top layer, will after that, soon dry out, upon which nitrification ceases, as we know. In the case of manure holes . . ., after a watering the sulphate is dissolved and will be absorbed in a thin layer around the sides of the hole, but at a depth where drying out will be gradual."

On the other hand, in Trinidad it is customary to scatter the sulphate of ammonia on the surface of the soil within or immediately around the stool. On certain plantations it is lightly covered with earth, but normally it is left as it lies. In view of the definite opinions of Earle and Quintus, an investigation has been made, under Trinidad conditions, of the effect upon yield of burying the manure. The investigation possesses added importance in view of the fact that very heavy showers of rain are common in the early wet-season, which is the usual time for applications of sulphate of ammonia to be made.

II.—Details of the Experiment.

Cane Variety and Age.—B.H. 10/12, first ratoons.

Soil Type.—A calcareous marl, neutral to slightly alkaline in reaction. It has been described elsewhere (4), (5).

Treatments (per acre) :—

(1) No manurial treatment.

(2) 3 cwts. of sulphate of ammonia buried by hand in furrows (dug with hoes to a depth of three inches around the cane stools), and then earthed over.

(3) 3 cwts. of sulphate of ammonia, applied by hand to the surface of the soil immediately around the stools and left uncovered.

The area as a whole received no tillage treatment, such as forking.

Layout.—Four 3×3 Latin Squares (*see* Table I).

Plot Dimensions.—22 feet (the bed width) by 79 feet (=1/25 acre).

Date of Application of Manure.—August, 1927.

Date of Reaping.—April, 1928.

Age of Ratoon Canes on Reaping.—11½ months.

Previous History of Experimental Area.—20 tons of pen manure were applied in 1925 to the plant canes in the furrows on breaking of banks. The yield of the plant canes in 1927 was 34 tons to the acre.

III.—The Yield Data.

The individual plot yields are recorded in Table I. The weights are given to the nearest quarter (28 lb.)

Table I.—Plan of Experiment with Plot Yields in quarters of 28 lb.

The treatment numbers are given in brackets.

Square I

(1) 72	(2) 96	(3) 80
(3) 120	(1) 64	(2) 66
(2) 104	(3) 96	(1) 52

Square II

(1) 96	(3) 52	(2) 92
(3) 94	(2) 63	(1) 101
(2) 98	(1) 81	(3) 83

Square III

(3) 92	(1) 60	(2) 96
(2) 114	(3) 80	(1) 56
(1) 84	(2) 100	(3) 102

Square IV

(3) 90	(2) 90	(1) 51
(1) 38	(3) 84	(2) 82
(2) 88	(1) 60	(3) 91

IV.—Analysis of Yield Data.

Use was made of the analysis of variance to allow for the variation between squares, rows, and columns, and to subdivide the effect of treatment into that due to :—

(*a*) the quantity of nitrogen applied.

(*b*) burying the nitrogen.

The completed analysis is set out in Table II. Full details of the method used are given in an appendix to the original paper (6).

Table II.—Analysis of Variance.

Due to		Degrees of Freedom.	Sum of Squares.	Mean Square.	$\frac{1}{2}\log_e$ (Mean Square).
	Squares	3	752.9	250.97	—
	Rows	8	623.3	207.77	—
	Columns	8	3784.0	473.00	—
Treatment	Quantity of N.	1	3799.0	3799.0	2.9700
	Burying	1	135.4	135.4	0.3031
Error	Interaction of Squares and Treatments	6 (14)	3352.3	283.16	1.0408
	Between parallel plots	8	612.0		
	Total	35	13058.9		

Standard Error of a Single Plot $= \sqrt{283.16}$

Standard Error for mean of 12 plots $= \sqrt{(283.16)/12}$

$= 4.858$

Results of Analysis.

According to Fisher's table of z (2), for $n_1=1$ and $n_2=14$, $z=0.7630$ when $P=0.05$, and 1.0909 when $P=0.01$.

Quantity of Nitrogen.—The difference due to treatment with nitrogen in Table II is 2.9700—1.0408, or 1.9292. *This difference might be due to chance far less than once in 100 times, and is therefore undoubtedly significant.*

Effect of Burying.—$\frac{1}{2}\log_e$ for burying is much smaller than for plot error. Consequently *the difference due to burying is definitely not statistically significant.*

Final Statement of Results.

Table III.—The Effect of Sulphate of Ammonia on Yield per acre.

cwt. of 112 lb.

With Sulphate of Ammonia.	Without Sulphate of Ammonia.	Difference.	Standard Error of Difference.
560.7 cwt.	424.5 cwt.	136.2 cwt.	42.95 cwt.

For $P=0.01$, $t=2.977$ when $n=14$ (2).

Significant difference $= 2.977 \times 42.95 = 128.72$ cwts.

The difference in yield due to treatment with nitrogen is definitely significant. It is equal to 32 per cent. of the mean yield from the unmanured plots.

Table IV.—The Effect of Burying Sulphate of Ammonia on Yield per acre.

cwt. of 112 lb.

Buried.	Unburied.	Difference.	Standard Error of Difference.
575.6 cwt.	545.6 cwt.	30.0 cwt.	42.95 cwt.

The difference in yield due to burying is definitely not significant. It might be due to chance about once in every two times.*

V.—Discussion and Conclusions.

(1) Effect of Quantity of Nitrogen.

There can be no doubt that the increment in yield of 6 tons 16 cwts. of cane to the acre, due to the application of sulphate of ammonia, is significant. This conclusion has been directly confirmed by a series of experiments set up in 1928, 1929 and 1930, and indirectly confirmed by the general increase in yield of sugar-cane per acre on those plantations in which the use of sulphate of ammonia has become a matter of routine practice.

(2) Effect of Burying.

The results obtained are of interest in that a very heavy shower of rain which amounted to over two inches in a few hours, and which flooded the plots, fell almost immediately after the application of the manure. The conditions, therefore, were extremely favourable to loss by wash of the superficial dressing. The analysis of the yield data indicates that any such loss on the plots receiving the third treatment, relative to that which might have occurred on the plots receiving the second treatment, is statistically not significant.

Quintus considers superficial applications inadvisable on the grounds that active nitrification does not occur when the top layer of soil dries out. It will be seen from the rainfall figures presented in Table V that, in the month preceding the application of the sulphate of ammonia and the following six months, the monthly rainfall did not fall below 4.25 inches, and, on occasion, exceeded twice this value. During this period it is unlikely that the moisture content of the surface layer of soil acted as a limiting factor to the supply of nitrate to the plant. The experiment therefore does not provide a valid test of the argument of Quintus.

Two other points which are worthy of mention arise in connection with the increment in yield due to burying. Firstly, that the increment of 30 cwts., although statistically not significant, is too large entirely to be disregarded on the basis of one experiment, carried out under a particular set of seasonal conditions. Secondly, that covering the manure may not be the most important factor contributing to the increment, and that the cultivation involved in the process of burying may play a major part. In view of these considerations the experiment is to be repeated, although certain modifications are to be introduced. For example a fourth treatment is to be included, identical with the second treatment except for the exclusion of sulphate of ammonia.

* t=Difference÷Standard Error=30.0÷42.95=0.7. When n=14 and t=0.7, P=0.5.

VI.—Summary.

(1) An account is given of an experiment initiated in 1927 to determine the effect on yield of sugar-cane (B.H. 10/12, 1st ratoons) of :—

(*a*) an application of three tons of sulphate of ammonia to the acre ;

(*b*) burying the sulphate of ammonia.

(2) The customary arguments in favour of burying the manure are quoted.

(3) The design of the layout of the experiment (four 3 × 3 Latin Squares) is described, and the method of analysis of the yield data recorded.

(4) By use of the "Analysis of Variance" it is shown that :—

(*a*) The increase in yield of 6 tons 16 cwts. of sugar-cane (or 32 per cent. of the mean yield on the unmanured plots), due to sulphate of ammonia, is definitely significant and might be due to chance less than once in 100 times.

(*b*) The increase in yield of 30 cwts. due to burying is statistically not significant and might be due to chance once in every two times, although rainfall conditions appeared very favourable to loss by wash of the superficial dressing.

Acknowledgments.

The author is indebted to Mr. G. B. Westwood of the Ste. Madeleine Sugar Co., Ltd., Trinidad, for permission to publish the data recorded in Table I ; to Mr. G. A. Jones at whose suggestion the trial was made ; and to Mr. K. McKenzie for his co-operation in the field work.

Table V.—Rainfall during the Period of the Experiment.

	Wet Season.						Dry Season.		
Month	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	April.
Rainfall (ins.)....	9.55	8.86	6.28	7.31	7.68	4.62	4.27	0.95	1.33	1.50

References.

(1) Earle, F. S. (1928).—"Sugar-Cane and Its Culture." *J. Wiley & Sons*, New York.

(2) Fisher, R. A. (1928).—"Statistical Methods for Research Workers." *Oliver & Boyd*, London.

(3) Quintus, R. A. (1923).—"The Cultivation of Sugar-Cane in Java." *N. Rodger*, London.

(4) Turner, P. E. (1929).—"The Lime Status of Soil in Relation to an Insect Pest of Sugar-Cane." *Journal of Agricultural Science*, XIX, 26.

(5) Turner, P. E. (1930).—"The State of Unsatu ation of the Soil in Relation to Its Field Behaviour and Lime Requirement". *Soil Science*, XXX, 349.

(6) Turner, P. E. (1932).—"Manurial Experiments with Sugar Cane."—I. Burying *v.* Non-Burying of Sulphate of Ammonia in Relation to Its Effect on the Yield of First Ratoon Canes. *Fourth International Congress of Sugar-Cane Technologists*, Porto Rico.

IMPRESSIONS OF A WEST INDIAN PLANTER IN CEYLON.

By Sir Norman Lamont, Bt.

During the early months of 1931, I paid two brief visits to Ceylon on my way to and from the Federated Malay States. The following article does not purport in any way to be a description of that wonderful Island. Its object is merely to record impressions which I received during far too short a time to acquire any real assurance. Those impressions, it will be seen, were mostly by way of contrast or of comparison with conditions familiar to me by long residence in Trinidad. A more extended sojourn might have modified—or confirmed—them. One of the strongest is my lasting impression of the hospitality and helpfulness of the planters, and of the Officers of the Department of Agriculture of Ceylon.

The Island of Ceylon lies between Latitudes 6° and 10° North; and is 270 miles long by 140 broad, with an area of 25,000 square miles. It is thus about 15 times as large as Trinidad, with a population of 5½ million, against the 400,000 of the latter island. The exports and imports each average about £30,000,000, say five or six times those of Trinidad. Its revenue amounts to about £8,000,000 against rather less than £2,000,000 in Trinidad. The revenue raised per head of the population is therefore only some £1 10s. 0d. in the larger and richer island, against £4 10s. 0d. per head in the smaller and poorer.

Ceylon gives the visitor the impression of greater prosperity than Trinidad. The architecture has a greater appearance of permanence, and is much handsomer, and more substantial. Stone, brick, and concrete are the usual building materials; roofs are generally of tiles, either of local manufacture, or imported from India; or else of Indian teak shingles. Wooden houses, with galvanised iron roofs, universal in Trinidad, are seldom to be seen in Ceylon. The general appearance of Ceylon, as one drives about the streets of the towns, or the country roads, is very much tidier; there are fewer unsightly posters and placards. Gardens, fences, hedges and lawns are better kept; and it is impossible to mistake cultivated for uncultivated land.

The wayside wild-flowers are almost all familiar to a West Indian. *Lantana*, of two species; *Mimosa pudica*, *Commelyna*, *Isotoma*, *Datura*, *Bryophyllum* ("leaf of life") *Bidens pilosus*; *Thunbergia alata*, Spider Lily (*H. tubiflora*), "Vervain" (*Stachytarpheta jamaicensis*), greet one familiarly on every side.

In Ceylon gardens the West Indian traveller feels equally at home. Crotons, Hibiscus, Bougainvilleas, Bignonias, Ipomaeas, Acalypha, Vinca, Coleus, Aralia, Poinsettia, Begonia, Caladiums, form the staple ornament of oriental as of occidental horticulture.

Ceylon fruits are largely the same as ours, but, in my experience, inferior in quantity, quality and variety. The best is the papaw, which appears at table regularly thrice-a-day. Bananas (locally known as "plantains") are definitely poor; so are avocadoes and the local oranges; more palatable oranges are imported from China, Palestine, and even California. Limes seemed scarce; mangoes and durians were unfortunately out of season during my visit.

"Ground provisions" and other tropical vegetables do not seem to find a frequent place on the bills-of-fare of Ceylon hotels, with the exception of ochroes, of very indifferent quality. European vegetables, grown in the hill-country, are generally excellent.

Travel in Ceylon is easy, agreeable, and well-organised. Not only are first-class hotels to be found in the larger centres of Colombo, Kandy, Mount Lavinia, and Nuwara Eliya, and smaller hotels elsewhere; but the 170 Government Rest-Houses, placed at twelve-mile intervals along the main roads, are admirably kept. Previous permission is not required as in Trinidad by the visitor desiring accommodation; the only condition being that his room must be surrendered if needed by a Government Officer on duty. The rest-houses vary greatly in size, according to the probable demand for accommodation in each locality. Their charges, however, are uniform, and very moderate, amounting to about 12*s.* 3*d.* per day.

The roads, covering some 16,000 miles, are well surfaced and extremely well graded. The roads in the hill-country are the result of magnificent engineering, of which the famous road from Kandy over the Ramboda Pass at 6,600 feet to Nuwara Eliya, is an outstanding example. With a perpendicular cliff on one side, and a perpendicular precipice on the other, there are stretches which do not appeal to a nervous motorist. Fortunately, however, the standard of driving in Ceylon is superior to that generally observed or experienced in Trinidad, otherwise suicide and manslaughter would materially increase Ceylon's average death-rate.

As is to be expected in so large an island, there is very great diversity of soil, climate and scenery. The coastal belt is flat, hot, and humid; while the interior rises gradually to the mountainous country of the Central Province, which culminates in Pidurutallagalla (8,292 feet). With so great a variety of altitude, climatic conditions vary from the cool temperature of the hill-station of Nuwara Eliya at 6,000 feet, through warmer Kandy at 2,000 feet, to the tropical heat of Colombo and the rest of the low country.

The Ceylon Government Railway presents another magnificent example of engineering skill. There are over 1,000 miles of 5′ 6″ gauge track. The main line from Colombo to Badulla reaches a summit level of 6,226 feet; rising, in one part,

no less than 5,000 feet in 83 miles, through an astonishing series of curves, bridges, viaducts, and tunnels. Sleeping-cars and restaurant-cars, of an European standard of comfort, are attached to the principal trains; and first-class compartments are fitted with electric fans. Features surprising to a Trinidad tourist are that it is not considered essential that every train should stop at every station; that omnibuses and lorries run in connection, and not only in competition, with the trains; and that steam rail-cars have been widely adopted.

Another method of transport is unexpected. Connecting a chain of lakes on the West Coast, there is a series of old Dutch Canals, forming a continuous waterway of 120 miles. The customary haulage is by means of man-power; labour is so cheap that barges of copra are hauled by four men 70 or more miles to Colombo, apparently at less expense than could be achieved by the application of motor-power to the barges, or by the railway which runs parallel to the canal.

Kandy, till 1815 the native Capital of Ceylon, is probably one of the most picturesque towns in the world. It is situated on the side of an artificial lake surrounded by wooded hills, and adorned by the famous "Temple of the Tooth" and other beautiful and historic buildings. Only four miles distant are the celebrated Peradeniya Botanic Gardens, of 150 acres in extent, and surrounded by a bend of the Mahaweli Ganga River. Adjoining the Gardens is the Central Experiment Station, under the skilled management of Mr. T. H. Holland; and the Peradeniya Farm School, which merits more than a passing mention, since it is the most important of the several Agricultural Schools of secondary grade. These schools are under the control of the Director of Agriculture, and are intended for training the sons of land-owners, future overseers, headmen, and elementary teachers in the theory and practice of scientific agriculture. Pupils are accepted at the age of 17, must be provided with a medical certificate of physical fitness, and must have obtained the English School-leaving, or a Cambridge Junior Local Certificate. The year is divided into four terms, and the fees amount to about £20 a year for board, lodging, and tuition. At Peradeniya about 60 students are in residence. Lectures are given in agriculture, botany, zoology, chemistry, animal husbandry, land measurement, &c., and the school farm comprises a useful little dairy herd of cattle, a poultry section, and apiary, a miniature paddy-field, terraced and irrigated, as well as plots of the staple crops, and of the more important garden produce. The course covers two years, and the Director of Education nominates twelve teachers every year as students to the school. Under the direction of Mr. Harbord and Mr. da Zylva, the Peradeniya School impressed me as a most valuable, and well-managed institution, well worthy of close and careful study by those responsible for the education of our agriculturists in Trinidad. As no less than 908 of the primary schools have registered school gardens attached to them, there is no lack of pre'iminary instruction of an elementary character.

Forests.

I travelled many hundreds of miles in Ceylon, largely through jungle; but I saw nothing which we should regard as "forest" or "high woods" in Trinidad. The jungle is denser than our "high woods", but seems to be composed of scrub, and trees of thirty, forty or fifty feet high; while our 150-feet or 200-feet giants are conspicuously absent. There must be primeval forest left, but Ceylon has been thickly inhabited for so long, that a large extent of the jungle is evidently of secondary growth. Unlike our forests, the Ceylon jungle is the home of a variety of wild beasts, including elephants, tigers, leopards, bears, deer, buffaloes, pigs and monkeys.

Hardly any of the jungle trees were familiar to me, but around the bungalows and villages one met such old friends as Saman, Terminalia, Grevillea (up-country), Cassia and Albizzia of various species, Ceiba or Kapok, while at the 6,000 feet level cypresses and *Rhododendron arboreum*, common in the west of Scotland, are features of the landscape. *Cedrela serrulata* or Red Toon, somewhat resembles our Trinidad "Cedar" (*C. mexicana*), but is a handsomer tree, with the notable red of its young foliage.

The West Indian is immediately struck by the absence of *Oreodoxa*, so prominent a feature in his native landscape, and by the clean stems and branches of trees in Ceylon, due to the absence of the hateful *Bromelia*.

Agriculture.

Now as to the principal crops grown in Ceylon. In order of area these are:—

1. Coconuts	.. ..	1,100,000 acres.
2. Rice	.. ..	800,000 do.
3. Rubber	.. ..	534,000 do.
4. Tea	.. ..	457,000 do.
5. Cacao	.. ..	34,000 do.

Even the immense area under rice is insufficient to grow all the rice required for the population; and Ceylon imports from India annually a quantity about equal to her own total production.

Tea.

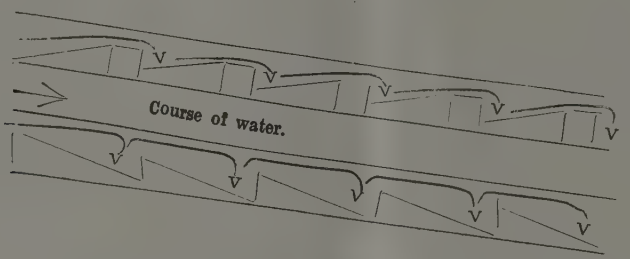
Tea on the other hand is grown entirely for export, and is the chief plantation industry of Ceylon. It dates from the later 70's of last century, when it began to arise on the ruins of the coffee industry.

The best tea-land is situated at an altitude of 4,000 to 6,000 feet, and is worth about £200 per acre. Quite ordinary tea-land is worth £100 per acre. Tea is grown down to about the 2,000 feet level; but below 4,000 feet the quality is inferior, though larger crops are reaped. The tea-plant is a shrub, which grows to a height of 10 or 15 feet when left for seed purposes, but, for cropping, it is kept down to about 3 feet high

by frequent prunings. It is planted at about 3×4 feet apart, or some 3,000 plants to the acre. It is plucked once every eight days, two leaves and the bud being removed from each shoot, collected in baskets, and carried to the factory, where it is withered, rolled, sifted, and graded. The best grade is known as Broken Orange Peko; then Broken Peko; next Orange Peko; fourth, Peko; and finally Peko Souchong.

The average crop of the best grades of tea harvested at the higher elevations is about 500 lb. per acre; while from 1,000 to 1,200 lb. of poorer grades may be expected on the lower ground.

Tea is grown under a very light shade of *Grevillea*, or of "dadap" (*Erythrina lithosperma*) annually pollarded for mulch. I formed a strong impression that more might be done in protecting the soil from erosion by the growth of leguminous or other green-crops. Tea is grown on very steep, sometimes amazingly steep, hillsides; and the amount of erosion that takes place during a heavy rainstorm is quite appalling to the frugal mind of a West Indian unacquainted with the practice of continual "clean-weeding", though as one ascends gradually from the plains, the colour of the rivers and torrents partly prepares one for a shock. Some of these steeper up-country tea-estates expend enormous sums annually in the purchase of artificial manures to compensate for the loss of the very best of their surface-soil thus carried away. In some districts the subsoil seems to consist of a soft rock, the gradual disintegration of which, under the influence of sun and rain, may partially compensate for the soil lost by erosion. Terracing is widely practised, in order to prevent, or at any rate to mitigate, the effects of erosion. And the "Lock-step system" of contour drainage,



and "Lock-step reversed", both act as a succession of silt-pits, and tend not only to conserve much soil that would be lost under ordinary drainage, but also help to release the surplus water gradually instead of running it all off at once.

When every allowance is made, however, for the effects of disintegration, terracing, and silt-pits, it is questionable whether the injury, if any, to the *crop* of a carefully selected and controlled weed-growth, such as *Oxalis*, might not, in the long run, be preferable to the injury to the *soil* of continued clean-weeding. It would appear to be a choice between loss of revenue or loss of capital.

Cacao.

As Ceylon cacao is known to fetch the highest price in the world, I naturally expected to learn much, both as to its growth and its preparation, nor was I disappointed. But if Trinidad has much to learn, there are certain points where she may also teach.

First with regard to the field. Cacao is not grown in Ceylon below the 500 feet contour, while most of it is to be found in the Kandy and Matale districts, between the altitudes of 1,000 and 2,000 feet, and with a mean annual rainfall of about 80 inches. The area devoted to this crop is about 34,000 acres, and the fact that, though profitable, it has not lately increased, is evidence that the Ceylon planter has not, like his Trinidad confrère, been tempted to extend its cultivation to unsuitable soils. The planting distance is generally 15′ × 15′* though sometimes as close as 12′ × 12′. The cacao is always shaded, usually with "dadap", though sometimes a larger admixture of "foreign" trees is permitted than on a Trinidad plantation. *Erythrina lithosperma* is less spinous than our two species, and its flower is of a deep crimson colour.

The pruning is very different from ours. First of all, the young trees do not appear to be shaped from the start; next, according to our ideas, the pruning is put off too long, and the trees are branched down to within two or two and a half feet off the ground, so that you do not see *through* a Ceylon cacao-grove, and it appears darker inside. Ceylon planters allege that, by pruning off all lower branches, we lose valuable bearing surface. On the other hand, it appeared to me that they have less "stem-crop". "Chupons" are sternly discouraged, and are slightingly described as "gormandisers". Our method of renewing trees by means of suitable chupons does not appear to be practised to anything like the same extent. On cacao estates, the system of frequent clean-weeding, though practised as on other cultivations in the East, has not generally had anything like such an injurious effect.

* Colonial Report, 1929, p. 19.

(Perhaps for the benefit of Trinidad planters one should explain that the monthly "clean-weeding" in the East is something quite different from chopping off the heads of weeds an inch above ground with a hoe—a sort of superior cutlassing—euphemistically known as "weeding" in the "Land of the Humming-Bird". In the East, the labourers have to get down on their marrow-bones, and pull even the very smallest weeds out with a "kurrandy" or with their fingers.) The protection afforded to the soil by the double shade, and double leaf-fall, of the "dadap" and cacao-trees, after the first few years, has prevented such serious erosion as on tea and rubber plantations. But even on certain cacao estates I saw steep hill-sides, whence all humus and surface-soil had been washed away, quite clamant for protection and regeneration by "Balisier."

So much for criticism. On the other side of the account, drainage, cultivation, and manuring, are all better than is usual in Trinidad. Contour drainage, often on the lock-step system, is as usual as on the tea-estates, for the Ceylon planters appear to realise, as ours do not, that the object of drains is as much to conserve water, or to release it slowly, as to get rid of it all at once.

Then the soil is generally forked lightly, every second year, often by women, who are less likely to fork too deep. Leaves, prunings, and shells are buried; and when walking over a field, one felt that the soil was soft, loose, and well worked.

In manuring, Ceylon resembles Grenada rather than Trinidad, for on all cacao estates a lot of pen-manure is applied; cattle being often kept solely for the purpose of supplying it. On most estates, moreover, forking is followed by an application of 700 or 800 lb. per acre of a "complete" artificial manure.

Yield.—It would be expected from the more careful selection of soil, and from the more intensive cultivation, that the average yield of cacao in Ceylon would exceed that obtained in Trinidad. Indeed the Ceylon Annual Colonial Report for 1929 claims (p. 19) that "the general average is about 3½ to 4 cwt. per acre". This estimate appears optimistic in the light of the Return of Cacao Exported, on p. 114 of the same Report, even after allowing for the local consumption of 7 tons of cacao weekly by the Peradeniya Chocolate Factory. Maclaren* asserts that "3 cwt. for the whole island has not yet been obtained, even in the record year of 1922", while the average has "often been below 2 cwt".

The actual yield on several estates which I visited varies from 4 to 5 cwt. per acre; while on certain favoured areas as many as 8 cwt. are undoubtedly obtained. The question is further complicated by the fact that, on considerable areas, cacao and rubber are grown together. So that, until a thorough statistical survey is made, such as is now being completed for Trinidad by the Economics Department of the Imperial College of Tropical Agriculture, the actual average yield in Ceylon must remain largely a matter of conjecture. My own impression is that 300 lb. per acre will be found not wide of the mark, as against the 255 lb. obtained in Trinidad, according to Gilbert.

Diseases.—Ceylon is fortunate in not suffering from witch-broom or cacao-beetle (*Steirastoma depressum*). Nor did I anywhere hear thrips complained of as a serious pest. Squirrels, however, are as predatory as with us, while canker is far worse on some plantations than I have ever seen it in Trinidad. This may be due to the heavy rainfall, heavily-branched cacao, and denser shade. Another abundant pest, unknown to us, is the Madagascar snail, which climbs the cacao trees, and devours their flowers; while its favourite beverage appears, most unaccountably, to be rubber-latex!

The "guatahel" is used, as in Trinidad, for picking cacao; but, for pruning, the bill-hook is preferred to the cutlass.

Manufacture.—The method adopted in Ceylon varies in many ways from ours. When it is brought in from the field, cacao is "sweated" for 14 hours (4 p.m. to 6 a.m.), then washed with water in cacao-baskets; and changed into another sweat box and left for 24 hours more. (The sweat boxes are in pairs, open at the sides). Then it is washed again, and trodden, in baskets. After this, it is spread out to dry on coconut matting, laid out in the sun on extensive barbecues, and brought in at night. This is continued for three or four days, the time of exposure being gradually reduced to two hours. The amount of labour required for this is enormous, but as men's wages are only about 9*d.* a day and women's less, the labour-bill matters less than in Trinidad.

Every estate has also its artificial drier; a long covered shed, with two layers of wooden slats covered with coconut matting, on which the cacao is spread. Hot air is driven by a fan through the building by means of pipes placed beneath each floor, and the temperature is kept at about 112°F.

There is no "dancing" of the cacao; and of course no "claying".

Sun-dried cacao is preferred to that artificially dried, and obtains a better price. A main object of the Ceylon method is to obtain a *pink* cacao, instead of our chocolate-coloured beans. This can only be accomplished by sun-drying; and cacao artificially dried has a whitey-brown colour far less attractive to the eye. Price depends a good deal on colour, and planters are particular in trying to obtain exactly the right shade of pink. Whether Trinidad cacao would obtain a price more nearly approaching Ceylon's if cured in the Ceylon way, is a question which appears worthy of investigation by the Department of Agriculture or the Cacao Planters' Association.

*Rubber, Tea and Cacao, pp. 104-5. The Resources of the British Empire Series. *Ernest Benn, Ltd.*, London, 1924.

After curing, Ceylon cacao is very carefully sorted into different grades. No. 1 beans are round, bright pink, with a light-coloured "cinnamon break", and are used for the finest confectionery.

It has long been a belief in Trinidad that the high price obtained by Ceylon cacao is due to its being a pure "Criollo" strain. This has, however, ceased to be more than very partially true; for since the introduction in 1878 of "Forastero" from Trinidad, that hardier and more prolific type has gradually displaced "Criollo". Many beans in the best Ceylon marks still exhibit the much-prized "cinnamon-break", but one may open a large proportion of beans indistinguishable in "break" from those of really good Trinidad cacao.

The nett result is that the Ceylon planter reaps a crop of say 300 lb. per acre against our 255 lb. that his labourers cost him 9*d*. a day against our 1s. 6*d*., that his taxation is £1 10s. 0*d*. per head per annum against our £4 10s. 0*d*., and that his cacao sells for £77 per ton against our £52 (average for whole crop of both colonies for 1929).

The continued existence of the Trinidad cacao industry under four such handicaps is surprising. It can probably be explained only by our greater economy of labour in production, and especially in curing. The Colonial Report of 1929 gives the average Ceylon labour-force as "one cooly for two acres", whereas Gilbert (p. 17) estimates "one man to five acres" as a probable average in Trinidad. Whether a larger expenditure on labour in improved cultivation might not be profitable in Trinidad is open to question, if not to experiment. There is no possible doubt that without the labour-economy of her sliding-roofs the cacao industry of Trinidad would perish in a season.

Coconuts.

Coconuts are the premier crop of Ceylon, and cover an area of over one million acres. The principal area is a triangle on the western side of the island, with a coastal base of about 75 miles from Chilaw to Kalutara, and reaching its apex at Giriulla, about 25 miles inland. There are also narrow strips of coconut cultivation on the south and east coasts, and a somewhat more extended area in the Jaffna peninsula in the north.

The best soils are alluvial flats along river-banks; and the next best are sandy loams, though even on pure sands, and on stiff clays, coconuts may be found apparently vigorous. The advantage of the more suitable soil appears to be even more marked in earlier maturity than in yield.

Very great care is exercised in the selection of seed-nuts from the best trees only. Seed-nuts are never brought from a distance, lest the "apple" should be spoilt by the shaking. In some cases, seed-nuts are even lowered from the tree in a basket. They are planted out from a nursery as soon as possible after germination. When the shoot is only a few inches high there is less risk of root injury. Holes are usually dug $3' \times 3' \times 2\frac{1}{2}'$ deep; but on some of the best estates cruciform holes $6' \times 6' \times 4'$ deep are prepared, with a filling of soil and husks, and 1 lb. or 2 lb. of artificial manure, or wood ashes, but care is taken to allow the mixture to settle thoroughly before the insertion of the plant.

Next as to planting distance. On the poor soils of the East Coast $22' \times 22'$ is usual, giving 90 trees per acre. On the better soils of the West Coast $26' \times 26'$ or 64 per acre, is a general practice. In view of the perennial controversy on this subject in Trinidad, and the confident assertions sometimes made, it was interesting to hear of an estate of 500 acres near Trincomalee, (East-Coast) where 250 acres had been planted $22' \times 22'$ and 250 acres $26' \times 26'$. The average return, with no manuring in either case, over a period of five years, was 38 nuts per *tree*; showing that, under those particular conditions of soil and climate, 80 or 90 acres had been thrown away by the wider spacing; in fact, worse than thrown away, for the waste acreage had to be cultivated.

Cultivation.—In Trinidad it is a misnomer to speak of coconut "cultivation". There is no such thing. The young palms on emerging above the sugar-cane, in which they spend the first five or six years of their growth, are usually allowed to fend for themselves, with such assistance as is rendered by two or three cutlassings of the undergrowth in each year.

In Ceylon, on the other hand, there are various methods of promoting the growth and health of the palms. During their early years, about six feet around each tree is forked twice a year. Thereafter the planter has the choice of five methods of cultivation.

(1) The whole field, or else alternate rows, may be ploughed and harrowed to within $4\frac{1}{2}$ feet of the trees; and the bare fallow kept clean of weeds.

(2) Cover crops may be *maintained* in the field; usually *Centrosema pubescens* or *Pueraria javanica*. 25 lb. per acre are sown, a quantity which has the effect of smothering weeds. The fallen coconut leaves are left on the ground and the husks (not shells) are carted back from the yard and spread in the field, where their decay is hastened by the damp of the cover-crop.

(3) On the poor, rather water-logged, sands of the East Coast there is little undergrowth. Here the practice seems to be to collect and to burn all leaves and husks; to apply the ash together with pen-manure and kainit in trenches between alternate rows.

(4) A fourth method is close-grazing the undergrowth with live-stock.

(5) A method which has much to recommend it is "radial trenching", practised on some very up-to-date estates. Starting at a circumference of $4\frac{1}{2}$ feet from the stem of the tree, the ground is divided into eight radial trenches, and two

THE VEGETATIVE PROPAGATION OF CITRUS.

Plate. III.

FIG. 7—*This shows root propagation in the West Indian lime. Shoots have developed from callus tissue at the proximal cut end and these have rooted abundantly. A detached shoot is seen on the left.*

FIG. 8.—*A rooted leaf cutting of Citron. This is a cutting of the first type and consists of leaf only.*

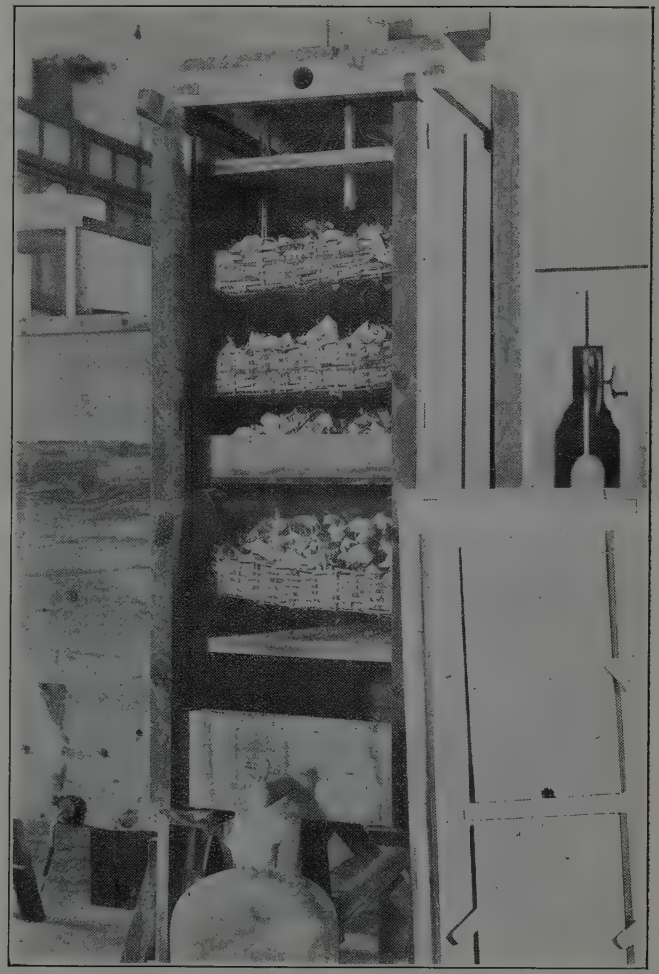
FIG. 9.—*Rooted leaf cutting of Citron. Second type of leaf cutting. The roots arise from a slip of stem tissue removed with the leaf*

FIG. 10.—*Developing leaf cutting of Rangpur lime ten weeks from setting. The cutting was of the second type and the shoot has developed from the bud in the axil of the leaf.*

QUICK VINEGAR PRODUCTION.

Plate I.

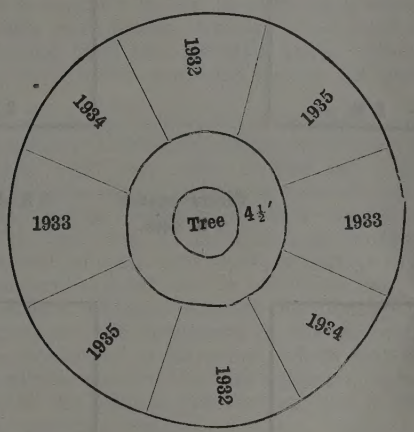
Exterior view of acetifier.



Interior view of acetifier showing nature and arrangement of filling materials, nicks, false bottom, central vapour tube, &c.

opposite trenches are forked in each of four successive years; weeds, leaves, and husks, being turned under. This method avoids the risk of injury to more than a quarter of the surface-roots at any one time. The resulting increase in yield in some cases has been remarkable.

Radial Trenching.



Heavy Manuring.—This is almost universally practised. For instance, Drieberg* states that so large a dressing as 4 lb. ground-nut cake, 6 lb. bone meal, 4 lb. fish manure, 2 lb. sulphate of potash = 16 lb. is sometimes applied to each tree every second year. Two pounds of a "complete" fertiliser annually is a more usual application.

On other estates, cattle are kept for their manurial value alone, and not used for milk, beef, or draught purposes. On one such estate 180 of small cattle, worth about £1 per head, are kept. They graze all day; are given a little rice straw only, and four of them are tied to a tree at night. On very light sand, the cattle do not "puddle" the soil.

Pests.—I saw no sign of either "wilt" or "redring" nor did I hear of their existence. † Two kinds of beetles appear to be prevalent: the Coconut butterfly (*Brassolis sophorae*) is present, but not to an injurious extent. A coconut moth (*Nephruntis seranopa*), unknown in Trinidad, is, however, a serious pest both in Ceylon and in Malaya. Wild pigs, elephants, porcupines, and other large wild animals need not preoccupy the West Indian planter.

The drainage of coconut estates appears to be as skilfully contrived and as well maintained, as on other cultivations in Ceylon.

Harvesting.—In the great coconut district of the Western Province, palms come into bearing at five or six years old while on the poorer soils of the East, as many as 13 or 14 years may elapse. Picking is carried out every two months, two bunches only being picked. The picking is done by men with incredibly long rods bearing a sickle-shaped knife, who become expert enough in balancing their clumsy weapons, to pick two bunches from each of 200 trees per day. The West Indian climber's "life-line" (fastened round the waist) does not seem to be known; but the "ankle-strap" method of climbing is used when palms are to be "cleaned" as well as "picked". The cost to "pick and clean" a thousand trees would be about £1 2s. 6d.; and a man would not accomplish a task of more than 100 trees per day.

After being picked, nuts are not husked in the field, but are carted whole to the yard, where they are heaped for a month before husking. The husks are then carted back to the field, and spread, or buried, to return to the soil. A man can husk 700 nuts per day for a wage of 8d.

Copra.—After being husked, each nut is split into two equal halves with the axe. A man's task would be about 4,000 nuts for 9d.

The next process is drying, which may be accomplished either by the sun, or in a kiln.

If sun-drying be intended, the nuts are split lengthwise with the axe, and the split halves are turned open to the sun, on coir matting, laid out upon the vast barbecue, or drying floor, which may be the size of about four tennis courts. At night, every half-nut has to be turned-down. This is done for two days. Then the copra is removed from the shell and again dried, for three days, or longer, if necessary, being turned up to the sun every morning, and turned down again at night.

For kiln-drying, the nuts are usually split crosswise, and are placed *backs* up. Otherwise the same procedure is followed.

The kiln consists usually of a brick building, open in front, with a grill six or seven feet above floor level. Parallel rows of shells (not husks) are laid twice-a-day upon the floor, and lighted from opposite ends. The shells burn for about five hours, and make less smoke than husks would do. But even so, the kiln-dried copra has a smoked appearance, and never obtains so good a price as sun-dried. Both sorts are very carefully graded, and are composed of half-kernels. On a good estate 95 per cent. of No. 1 copra will be obtained, in unbroken halves. The copra produced in the form of chips and fragments so often seen in Trinidad would be quite unsaleable in Ceylon.

The "Chula" drier is not often seen in Ceylon, and appears to be unpopular because of its high initial cost. On the other hand, no regard appears to be paid to the enormous cost of labour involved in the barbecue system of drying.

More attention is given to the manufacture of bye-products in Ceylon than in the West Indies. For instance, "coir" is an "important* but somewhat unorganised industry". Then "Cadjans"

* Plâté, "Ceylon", p. 45.

† This was in January-March: "Wilt" seems to have made its appearance in September. *Tropical Agriculturist*, Vol. LXXVIII, No. 1, Jan., 1932.

* Colonial Report, 1929, p. 18.

for thatching, are made upon most estates. Cadjans are the plaited half-leaves of the coconut-palm, and an expert woman-worker can make 100 cadjans from 50 leaves in a day for 1s. 3d.

Then on some estates a permanent brick kiln has been installed for the manufacture of charcoal from coconut-shells. This is the very best quality of charcoal made, and is worth about £2 12*s.* 6*d.* per ton, made, at a cost of only 7*s.* 6*d.* from about 23,000 shells.

Yield.—On the excellent coconut-soils of the Western Province 50 nuts per tree might be taken as an average yield, while on the best-managed estates 60 or 70 nuts per tree is not an unusual crop. On one heavily-manured plantation of 1,280 acres, the crop in 1929 was six million nuts, 5,000 nuts per acre, or 78 per tree.

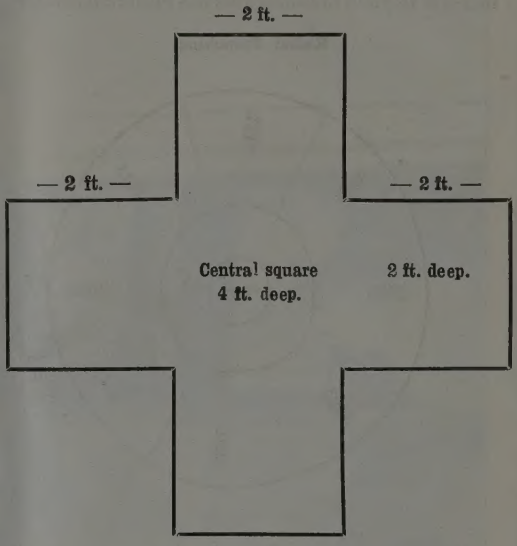
Desiccated coconut is produced in Ceylon on a large scale. Mills, sometimes dealing with as many as 60,000 nuts a day, are to be met with in almost every district, so that the transport and delivery of absolutely fresh nuts, essential to high-class production, can be effected with economy, speed and regularity.

In coconut growing and the manufacture of copra, just as in the case of cacao, the contrasts between the methods of Ceylon and Trinidad are more obvious than the resemblances. Profitable production appears to be sought by the Ceylon planter through increase of revenue, while his Trinidad competitor seeks the same end through reduction of expenditure.

Rubber.

Though an enquiry into the precarious situation of the rubber industry was the object of my journey to the East, this crop is of such very minor importance in Trinidad that it may be disregarded in an article intended primarily for West Indian readers. Three points may, however, be noted. First, the really appalling destruction of soil-capital, brought about by a quarter-century of clean-weeding, with its resultant erosion, has been checked, and indeed reversed perhaps more, on the rubber-plantations of Ceylon than elsewhere, by a widespread growth of cover crops such as *Dolichos hosei* and *Centrosema pubescens*. One may see miles of country covered, beneath the rubber trees, by a level leguminous carpet, without the vestige of a weed showing through. The second point is the notable progress of bud-grafting from proved clones, and the increasing yields thereby already obtained.

A third point, immediately patent, is that tea and rubber are similarly shipped in square wooden chests, although the former is for direct internal use, the latter only for external application to the sole or the tyre. It would seem a somewhat obvious economy, for a distressed industry (would dealers only permit), to ship rubber *baled*, seeing that transport in jute sacks does not render either cacao or coffee unsafe, unsaleable, or even unpalatable for internal consumption.



Cruciform hole for planting Coconuts.

BIRD MIGRATION.

Professor Ballou recently forwarded to the Bureau of Biological Survey, U.S.A. Department of Agriculture, Washington, D.C., a band numbered B316087 recovered from a sea bird which was found by Major de Pass on the east coast of Trinidad (Manzanilla beach). Subsequent information received from the Bureau indicates that the bird carrying this band was a young common tern which was banded on 27th June, 1931, at Tern Island, Chatham, Massachusetts.

Important investigations relative to the migration and other facts in the life histories of North American birds are being carried out by the Bureau by means of numbered metal bands. These are attached to the birds by volunteer co-operators, both in the United States and Canada. Large numbers of migratory waterfowl and small song birds have been banded in this way at more than 50 stations scattered over the continent and many interesting facts about their movements have already been discovered.

The Bureau of Biological Survey would be glad to receive further reports of any banded bird that may be recovered in this Island or elsewhere. Such reports should indicate the number of the band (with designation, if any, A, B, &c.), date of recovery, and the locality.

CHEMICAL NOTES.

Compiled by the College Department of Chemistry and Soil Science.

Babassu Oil in Brazil.

Babassu oil is slowly replacing coconut oil for edible and industrial purposes throughout Brazil. Babassu or baguassu oil is the product derived from the kernels of nuts of the babassu palm, which is botanically known as *Orbignia speciosa, O. martiana and Attalea speciosa*. This plant is quite distinct from the piassaba palm, *Attalea funifera*, with which confusion has in the past occurred.

The oil of babassu is present as about 66 per cent. of the weight of the kernels, which are themselves only about eight per cent. of the nut. The remainder of the nut is largely made up of a very tough skin and an endocarp, which is capable of yielding 30 per cent. of metallurgical charcoal, eight per cent. of acetic acid of 80 per cent. purity, eight per cent. of tar, and a small amount of methyl alcohol, when subjected to dry distillation.

A factory for the distillation of the endocarp has been established at Maranhao, which may be considered the centre of the very extensive region over which the babassu palm grows, and is the principal exporting port.

Hand crushing of the nuts can give as a maximum a daily yield of only 50 kilos. of kernels. Some progress has been made with the design of machinery for crushing, but the problem of satisfactory separation of the kernels is not yet solved. The babassu palm is abundant in Brazil and Bolivia, so that the wider utilisation of this source of edible vegetable oil may be said to depend solely upon the engineer; the actual extraction and refining of the oil present no difficulties, and the cake forms excellent cattle food.

The similarity of babassu oil to coconut oil is striking; the resemblances extend even to the composition of the fatty acids. The following constants and data are derived solely from six analyses of Brazilian oil of babassu made in Brazilian laboratories; they agree well with earlier determinations made by the Imperial Institute and others in Britain.

Specific gravity at 15°, 0.913-924; at 100°/15, 0.868-869. Refractive index, 40°, 1.4463-1.4502. Butyro refractometer reading of commercial crude oil, 33-36.3; of refined oil, 36.5. Iodine value (method not given), 7.4-15.15; Hubl (one sample), 17.4. Saponification value; one sample gave 236.0 for the oil and 258.6 for the fatty acids; a refined sample gave 254.8, and two commercial crudes, 260 and 263; other values were 246.6 and 249.1. The solidifying point varied from 17.4° to 22°; the melting point from 22.5° to 28°—this last being a refined oil.

Individual values for an oil studied by Snr. Arie were: Reichert-Meissl value 8.8, and Polenske value 4.4.—(*Arch. do Inst. Biol.* (*Sao Paulo*), Vol. IV, 1931.)—(*Ind. Chem.*, Vol. VIII, No. 84, p. 35.)

The Food Value of Beer.

In the *Journal of the Institute of Brewing* for February, 1932, Chaston Chapman gives the results of an extended study of the dietetic value of beer (1). The energy value is capable of accurate determination, and it forms a basis for comparison with "solid" food. For a man doing moderate work, two pints of beer of the strength of ordinary bitter beer will contribute about one-sixth of the total energy required daily, and a quart of good average beer contains as much energy value as half a pound of bread, two-thirds of a pound of beef, and over one pound of potatoes. There are other qualities of beer which cannot be valued mathematically, but which are of considerable importance, namely, the stimulating effect of the alcohol and the dissolved carbon dioxide gas, the tonic and soporific effects of the hop constituents, and the beneficial effect of the small quantity of mineral salts present.

In this connection it is appropriate to refer to a lecture entitled "Recent Advances in the Fermentation Industries", by J. Vargas Eyre (2). According to Eyre, quality in beer depends upon several factors which are currently recognised as falling into two groups. The flavour, colour and aroma, though influenced by the barley, are mainly determined by the conditions of malting, hopping and fermentation; while head retention, palate fullness, and both colloidal and biological stability are in varying degrees largely dependent on the nitrogenous substances derived from the original protein of the barley. The control of temperature and of hydrogen ion concentration have enabled the brewer to utilise other enzymes present besides the starch-hydrolysing Amylase, while gas-retaining properties, head retention, and possibly also the flavour, have been found to depend to a large extent upon certain colloidal constituents which have the power of retaining carbon dioxide.

The preparation and propagation of pure cultures of the special yeast for brewing is now regarded as one of the most important phases of the process, if the highest yields are to be obtained.

(1) Abstracted in *Chemistry and Industry*, Vol. LI., 1932, No. 12, p. 238.

(2) Streatfield Memorial Lecture, 1931, published by the *Institute of Chemistry*, 30, Russell Square, London, W.C.1.

ERRATA.

Sugar-Cane Research.

March 1932: Page 61, column 2, line 26. For *the principal author of which is Mr. B. A. Foster*, read *the authors of which are Mr. A. Wood and Mr. J. H. Gorvin.*

Panama Disease.

On page 86, Vol. IX, No. 3, first column, line 20, *does not normally extend as high as soil level in bananas* should read *does not normally extend as high as soil level except in bananas.*

TREND OF THE MARKETS.

[*The notes below are based principally upon running charts of the prices of the basic grades and upon general statistical information gleaned from contemporary publications and cablegrams and are intended to be a record of movements. An attempt is made, where possible, to indicate the market outlook at the time of going to press, but no responsibility for the accuracy and subsequent truth of such observations is assumed. Unless otherwise stated the prices quoted are spot, London.*]

SUGAR.—Prices on the Home Market have ranged as follows (c.i.f. per cwt.) :—

	Foreign.	*Preferential.*
	s. d.	*s. d.*
25th February ..	6 3	9 11¾
3rd March ..	6 3	10 0
10th March ..	5 4½	9 1½
17th March ..	5 3	9 0
24th March ..	5 3	9 0
31st March ..	5 1½	8 10½
7th April ..	4 3¾	8 1½
9th April (1931)	6 6¾	10 4½

Markets have been in a highly nervous condition during the past month owing to the uncertain course of events in Paris and the apparent collapse of the Chadbourne restriction scheme. Prices have thus continued their downward movement and new low records have been broken. The breakdown of the scheme might possibly lead to an improvement as it would mark the end of a long period of uncertainty. The period, however, required to attain such an improvement would not only depend on the extent of voluntary restriction of output but also on world economic conditions as affecting consumption. *Messrs. C. Czarnikow* state that stocks in the European statistical countries are at present 900,000 tons lower than a year ago.

* * *

COCOA.—The cocoa market continues extremely quiet and prices are easier, Accra fair fermented being quoted at 31*s.*, 32*s.* f.o.b., whilst locally $7.10 a fanega is generally paid.—(*By courtesy of The Cocoa Planters' Association of Trinidad.*)

* * *

COFFEE.—Fairly large supplies have been offered at auction, Costa Rica 136*s.* 6*d.* and Kenya 112*s.* being well represented. The first arrivals of Blue Mountain have just taken place. Parcels of good ordinary Jamaica have been worth about 65*s.*

* * *

TEA.—Latest tea averages include Ceylon 15.12*d.* Indian 10.37*d.* Java 7.66*d.* On the whole prices have been disappointing.

* * *

COPRA.—The market has been very irregular and though there have been favourable reactions, prices at the close of March were at about the worst point of the month. West India £16 5*s.* 0*d.* per ton, c.i.f. London.

RUBBER.—Quotations for Plantation Sheet have ranged as follows :

	d.
24th February	2 1/16
2nd March	2¼
9th March	2¼
16th March	2⅜
23rd March	2
30th March	1 15/16
6th April	1 13/16
7th April (1931)	3¼

The failure of the Anglo-Dutch scheme of restriction precipitated a further decline in the value of Sheet to the low price of 1¾*d.* per lb. It is believed that under existing conditions the price is likely to remain low for at least a year or two.

* * *

COTTON.—The following are the official spot prices in pence per lb. of the Liverpool Cotton Association :—

	American Mid.	*Egyptian F.G.F. Sakel.*
26th February ..	5.79	7.80
4th March ..	5.73	7.80
11th March ..	5.51	7.40
18th March ..	5.51	7.45
24th March ..	5.15	—
1st April ..	4.81	—
8th April ..	4.73	—
10th April (1931) ..	5.59	9.00

Generally speaking, fundamental conditions in cotton do not show any great change although prices have shown a tendency to drop slightly, the decline being helped by the quick advance in sterling. The *West India Committee Circular* reports that there has been a little more enquiry for West Indian Sea Island with a few sales in St. Vincent at 11½*d.* to 12*d.*

* * *

BANANAS.—There is no improvement in the demand and prices are unchanged at : Jamaicas £17 5*s.* per ton delivered London, £17 delivered nearest railway station ; and Brazilians £17.—(*West India Committee Circular*, 17th March.)

* * *

ARROWROOT.—A small business is passing at the fixed prices of 3*d.* to 3½*d.* for good ; 3½*d.* to 4*d.* for fair ; and 4*d.* to 4½*d.* for super-fine according to quantity.—(*West India Committee Circular*, 17th March.)

* * *

LIME OIL.—Small sales of handpressed at 55*s.* and distilled at 32*s.* 6*d.* per lb., landed terms.

* * *

ORANGE OIL.—Neglected. Sellers of Sweet Jamaica at 5*s.* c.i.f.